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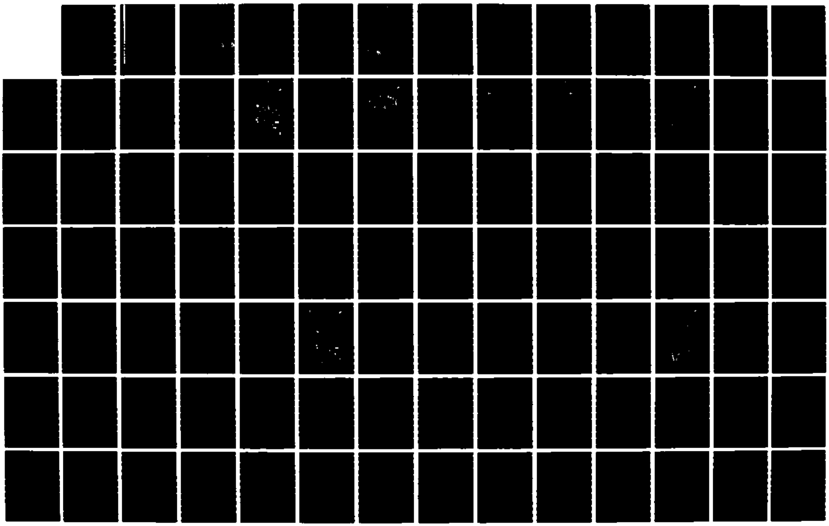

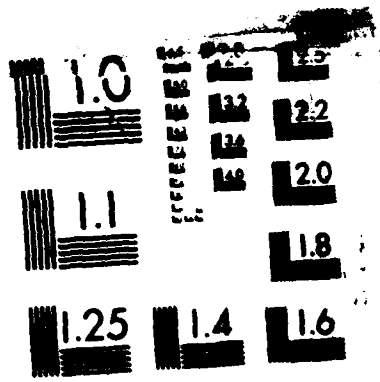

MICROCOPY RESOLUTION TEST CHART

CASTLE AFB
PHASE II, STAGE 1 IRP
FINAL REPORT
SECTION 4 THROUGH
SECTION 7

Unclassified
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A problem confirmation study was performed at Castle AFB and included 21 potential contaminant source sites identified in the Phase I Report as requiring field investigation. The potential source sites were grouped into 16 investigation sites including the area of a confirmed plume of TCE contamination in groundwater. The field investigations, conducted from October 1984 to April 1985 included installation of 27 new monitor wells and 11 shallow lysimeters, collection of sediment samples from surface soil, shallow borings, and drainage ditches, geophysical surveys of three sites, two rounds of surface and groundwater sampling and water level measurements, and pilot test operations on a Base production well. Analytes include volatile organic compounds, TOC, TOX, oil and grease, as well as phenols, nitrate, metals, pesticide and herbicides at selected sites. Of the sixteen sites investigated, twelve were recommended for further groundwater study, either through continued monitoring of existing wells, or through expansion of the monitoring network. The TCE plume in the shallow aquifer was delineated and recommended for immediate (con't. on back)

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feasibility study; additional investigation to locate the source of the plume and to define its extent in off-Base areas and in an underlying aquifer have also been recommended.

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SECTION 4

RESULTS AND CONCLUSIONS

4.1 SITE INTERPRETIVE SOILS AND GEOLOGY

Based on observations of excavated mud pits and soil samples from auger borings, soils in the upper 10 to 20 feet below land surface were found to consist primarily of brown and yellowish-brown fine-to-medium sand with occasional layers of sandy silt and grey or olive-colored clay. The clay and silt content of soils was found to increase somewhat in the East and North Sectors. Hardpan, when encountered, consisted of cemented medium sand; the cementing matrix was generally composed of dense silt and occasionally of iron oxides. In structure, the hardpan was found to consist of relatively thin (2- to 6-inch) intermittent layers with nonindurated sand layers between them. Little homogeneity or lateral continuity was found in the hardpan layers. Only once were saturated (water-bearing) stringers of sand found at shallow depths in the two soil borings at Site DA-4. The two deepest auger borings, next to MW-260 in the South Sector and MW-360 in the North Sector, were drilled to total depths of 21.5 feet without encountering either hardpan or saturated (water-bearing) sands.

Additional information on the shallow subsurface down to 120 feet was obtained from 27 mud rotary boreholes drilled for monitor well installation. Geologic logs for these boreholes (Appendix D-1) can be correlated with logs for the existing test wells (Appendix D-3) and other available Base well logs (Appendix D-4 and Subsection 2.3.3) to provide a detailed picture of shallow subsurface geology for most of CAFB.

Figure 4-1 shows two generalized geologic cross-sections through the area of CAFB developed from monitor well logs and some existing logs. The lines of cross-section, shown in Figure 4-2, approximately follow the lines of the regional cross-sections in Figure 2-7. Section AA-AA', approximately paralleling the southwestern Base boundaries, indicates that the shallow aquifer intercepted by monitor wells in the South, Main Base, and West Flightline Sectors consists of a continuous bed of coarse round gravel in the northwest grading to coarse sand and

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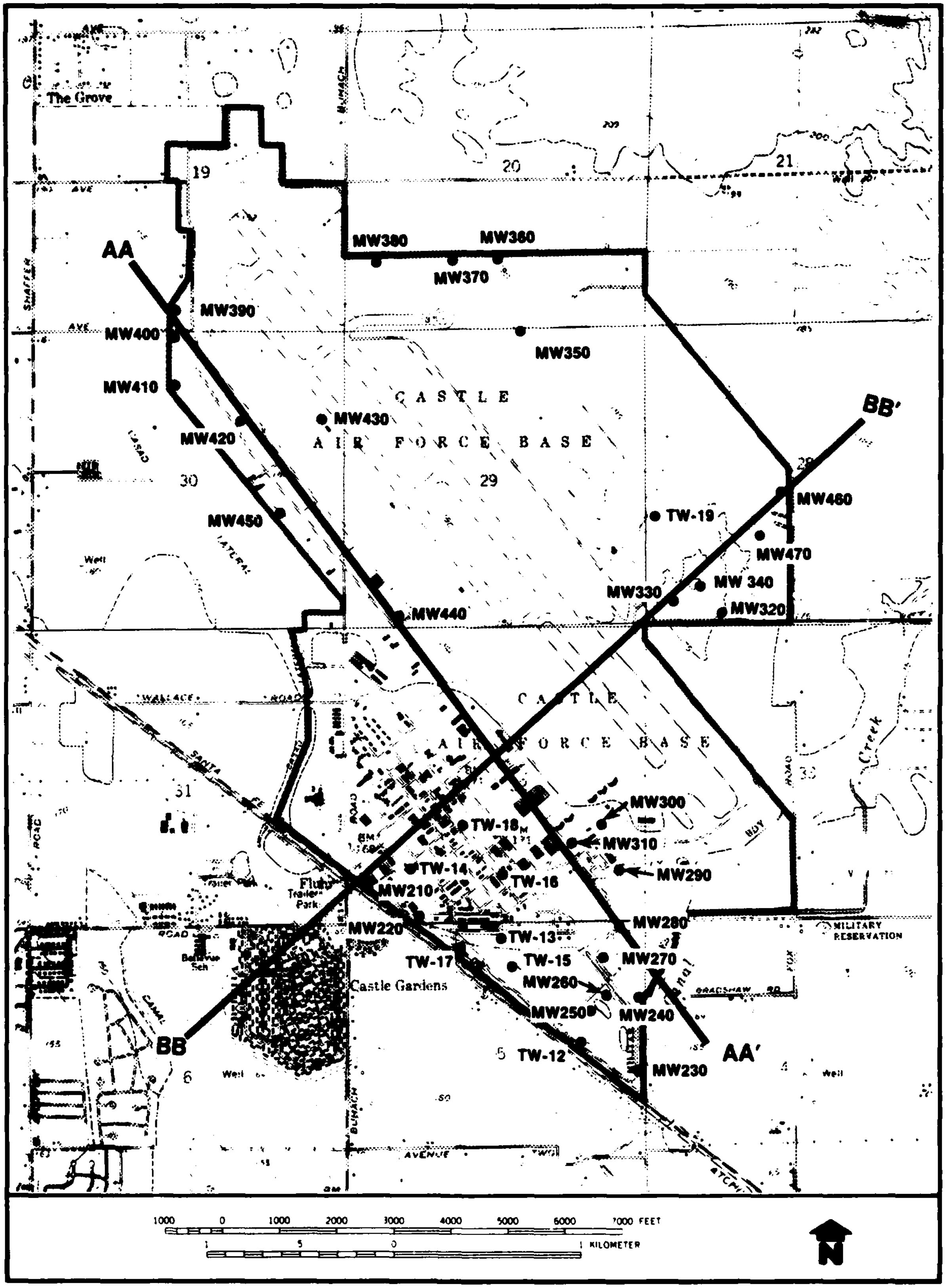


FIGURE 4-2 LOCATION MAP FOR GEOLOGIC CROSS-SECTIONS AA-AA' AND BB-BB'

then back to gravel in the southeast; it is 20 to 50 feet thick, averaging about 22 feet in most places, and occurs consistently along the cross-section between depths of 70 and 100 feet. It is overlain by a bed of clay which is continuous along the cross-section, although it appears to be pinching out to the southeast. The clay is 30 to 40 feet thick and interfingers the underlying sand and gravel. In most places along the cross-section, there exists a transition zone of finely-interlayered sands and clays above and/or below the clay bed. Most frequently, the clay is rust-brown silty clay overlying grey, olive-grey, or olive-green plastic clay. It is found most often between depths of 30 and 60 feet along the line of cross-section.

Section BB-BB' indicates that the sand and gravel layer dips and thickens to the southwest. Sand layers encountered below 40 feet in the northeast were thinner, more-finely interlayered with clays, and exhibited less lateral continuity than the coarse sand and gravel layer encountered in the southwest. A single exception to this generalized description of the subsurface geology in the North and East Sectors was encountered in MW-350 (northwest of line BB-BB'), which appears to have been drilled in a deep channel cutting through the interlayered sands and clays and filled primarily with coarse calcareous sand from 13 to least 113 feet. The shallow clay layer overlying the main sand and gravel body in most of the East and North Sectors also appears to dip southwest, pinching out under the Main Base area, so that sand (with interlayered silty sand and hardpan) is found continuously from the surface down to 70 feet, and immediately overlies gravel in MW-210.

In general, the shallow sand and gravel aquifer layer beneath CAFB is underlain by clay in the southeast and southwest, and by finely interlayered clays and sands in the northeast and northwest. The top of the clay found underneath the aquifer in the South and Main Base Sectors occurs at elevations between 80 and 90 feet MSL. Based on the cross-sections A-A' and B-B' in Figure 2-7, this clay appears to correlate well with the Corcoran clay member identified by Page (1977), which dips to the southwest and has been interpreted to pinch out 2 to 3 miles south of the Base boundary. If extended under the Base, this clay member would occur at a depth of approximately 65 to 80 feet MSL. A careful review of geologic logs available for off-Base wells to the southeast would be required to confirm this correlation.

The clay layer overlying the sand and gravel shallow aquifer layer correlates well with the shallow clay bed identified by Page (1977). However, it was not found to occur continuously beneath the Base, and in many cases, it includes finely-interlayered sand stringers. Where present, it serves as a confining layer and a barrier to vertical flow over the shallow sand and gravel aquifer. Therefore, the shallow aquifer should be considered semi-confined.

Additional detail on subsurface lithology as it influences groundwater conditions on a Base-wide and sector-by-sector basis is provided in the following subsections.

4.2 SITE GROUNDWATER CONDITIONS

4.2.1 Aquifer Description

As described in Subsection 2.4.1, three water-bearing zones, or aquifers, can be distinguished beneath CAFB. The new production well draws water from the lower-most aquifer at a depth of approximately 800 feet. The older production wells draw water from a confined aquifer at 260 to 300 feet below ground surface, and in the East Sector from a shallow aquifer at 80 to 120 feet below ground surface. This investigation focused on the shallow aquifer as the most-likely receptor of contamination originating at or near ground surface.

In the West Flightline, Main Base, and South Sectors, the shallow aquifer consists of a layer of coarse unconsolidated stream sediments 10 to 50 feet thick, ranging in grain size from well-sorted medium sand to coarse, rounded gravel. This layer dips to the southwest and thickens into a wedge. To the northeast, it slopes upward or pinches out, so that the shallow aquifer in the East and North Sectors consists primarily of clays and silts with relatively thin interlayers of water-yielding sands exhibiting little lateral continuity. Water-bearing sands and gravels are overlain by clays forming a confining layer over much of the aquifer. In general, this layer thins and pinches out to the southwest and grades upwards into interlayered clays and sands. There may be locally-saturated sands in "perched" zones over the confining layer, but this could not be confirmed with mud rotary drilling methods. It had been hypothesized in the Phase I report that hardpan layers occurring between 5 and 15 feet might create locally-perched zones at very shallow depths. Hardpan zones encountered in this investigation, however, were found to exhibit little lateral continuity, and the 11 "lysimeters" finished on top of hardpan were observed to be dry during both late January and early April groundwater sampling rounds.

4.2.2 Water-Level Fluctuations

Groundwater level fluctuations in the shallow aquifer during the period of investigation are illustrated in the hydrographs for selected wells in Figures 4-3 and 4-4. These figures are useful in making a preliminary grouping of wells according to different groundwater regimes, and in evaluating the factors influencing these regimes. Water levels in the wells in the Main Base Sector (TW-14, TW-15, TW-16, MW-210, MW-220, and MW-300) followed a similar trend, rising slightly in December, falling slightly in January, rising more sharply in February and March, and falling again in early April. Water levels in these wells may have been influenced to some degree by cessation

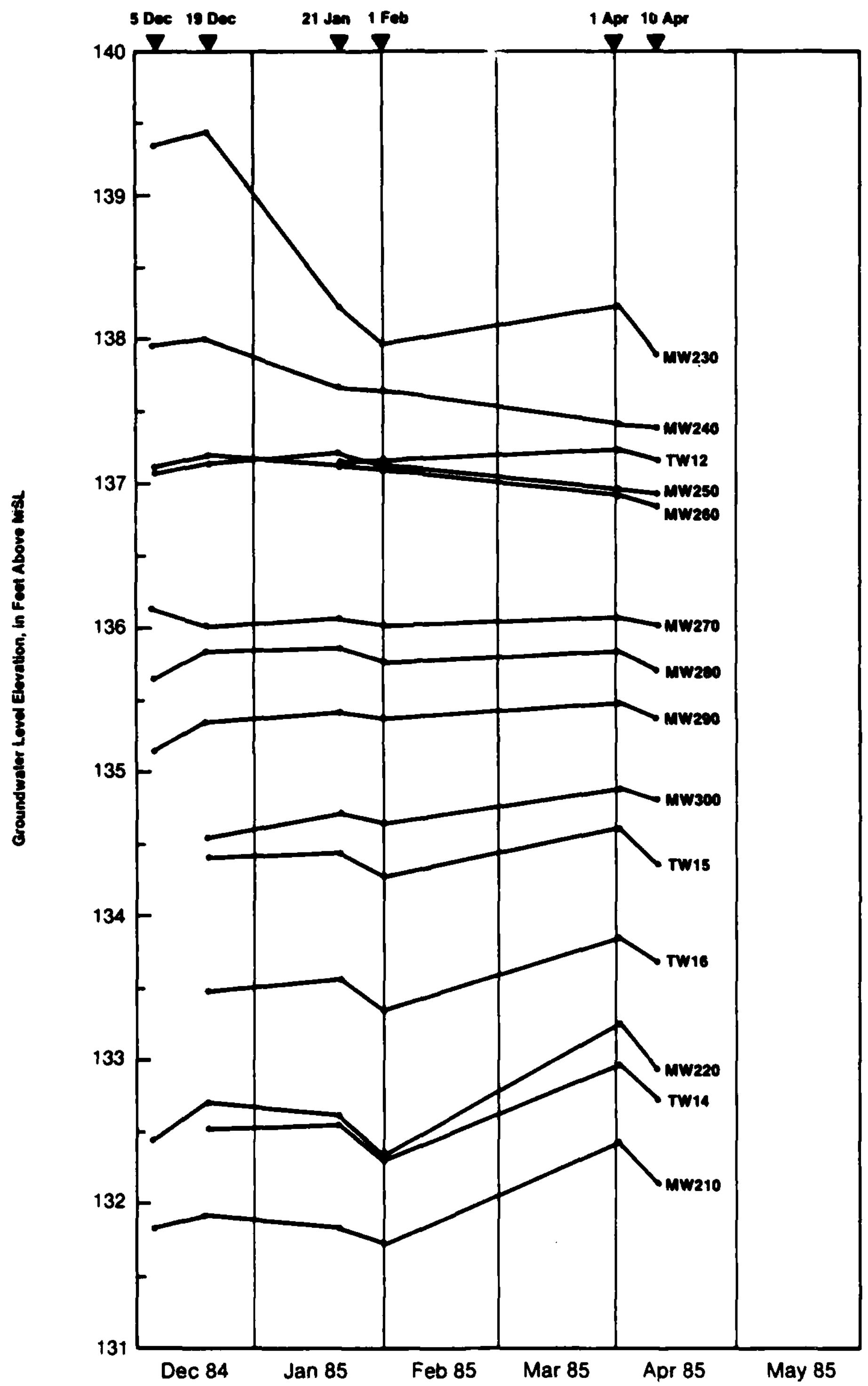


FIGURE 4-3 WELL HYDROGRAPHS, MAIN BASE AND SOUTH SECTORS

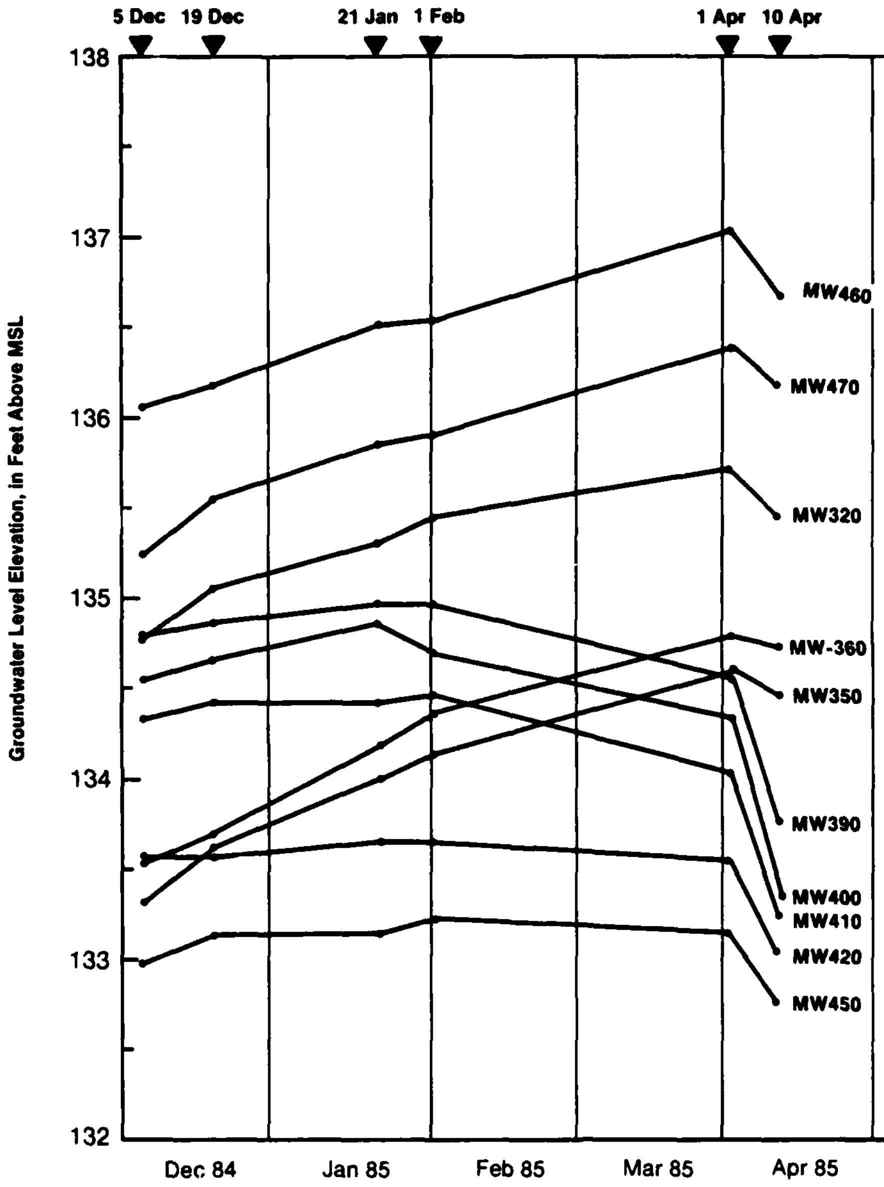


FIGURE 4-4 WELL HYDROGRAPHS - EAST, NORTH AND WEST FLIGHTLINE SECTORS

of all pumping from the Main Base production wells, which occurred in early February. Although the production wells produced water from the confined aquifer, they are assumed to have induced some leakage from the shallow aquifer, and therefore to have had a long-term influence on water levels in both aquifers. Water levels in wells in the South Sector (TW-12, MW-230, MW-240, MW-250, and MW-260) tended to decrease between December and April, with the most-pronounced decline (1.5 feet) occurring in MW-230, on the southeastern corner of the Base. These wells are most-likely influenced by steady infiltration from spray irrigation on the landfill, and an increase in evapotranspiration rate in the spring, resulting in a decrease in net recharge between winter and summer. In addition, the influence of such off-Base factors as leakage from adjacent canals, and start-up of irrigation pumping would be felt most strongly by the wells on the Base boundary (MW-230 and MW-240). Water level trends in three wells (MW-270, MW-280, and MW-290) were transitional between the Main Base and South Sector regimes.

Water levels in wells in the East and North Sectors (MW-320, MW-350, MW-360, MW-460, and MW-470) followed parallel trends, rising from December through March and falling somewhat in early April. These wells are least likely to be influenced by off-Base or man-made factors, and should therefore be considered most representative of the natural aquifer regime. Three wells on the Base boundary in the West Flightline Sector (MW-390, MW-400, and MW-410) were found to exhibit a significantly-different water level trend, rising in December and January and falling in February, March, and April. Water levels in the three wells fell from 0.7 to 1.0 feet between 1 and 10 April 1985. Water levels in these wells were obviously influenced by pumping from an off-Base irrigation well just across the boundary from MW-400. However, the location and investigation of other off-Base pumping wells potentially influencing water levels in the shallow aquifers was beyond the scope of the present investigation. Other wells in the West Flightline Sector (MW-420 and MW-450) exhibited water level trends that can be considered transitional between the Main Base and West Flightline regimes described above.

4.2.3 Groundwater Flow Direction and Velocity

The groundwater level maps for the shallow aquifer in Figures 4-5 and 4-6 were developed from water level data collected on 18 and 19 December 1984, after completion of monitor well development, and on 10 and 11 April 1985, at the end of the second round of water sampling. These figures are contour maps representing the piezometric surface in the shallow aquifer, showing the distribution of hydraulic head in that aquifer. Groundwater flows from areas of high to areas of low hydraulic head and, in general, the direction of groundwater flow is perpendicular to groundwater level contours. Based on these maps, it appears that groundwater flow in the shallow aquifer converges from the northwest, northeast, and southeast toward the Main Base Sector, exiting the Base area along a relatively short segment of the southwest boundary. This configuration may be controlled to some degree by lithology: both the permeability and thickness of the aquifer sediments increase to the southeast, resulting in an increase in aquifer transmissivity. Furthermore, MW-350 was drilled into a relatively high permeability channel cutting through mixed sediments of relatively low permeability. Zones of higher transmissivity in an aquifer can act as regional "drains," drawing water from surrounding zones of lower transmissivity (higher resistance) to a flow zone of lower resistance. In addition, the configuration of the piezometric surface is probably influenced by off-Base pumping from wells screened in the shallow aquifer.

Differences between the two maps are related primarily to an increase in water levels in the North Sector between December and April, a decrease in water levels in the South Sector, and the start-up of off-Base pumping near the northwest boundary, resulting in a significant decrease in water levels in this area. The northwest boundary is the only area in which a significant change in groundwater flow direction was observed to occur seasonally. In winter, the flow direction along the northwestern boundary is primarily to the southeast, parallel to the boundary. In the spring and summer, groundwater flow in this area would be to the west-southwest, toward areas of off-Base pumping, including the irrigation well just across the boundary from MW-400. As a result, the portion of the Base boundary along which groundwater underflow exits the area of the Base is effectively lengthened during the spring and summer months, to include most of the west-northwest boundary line.

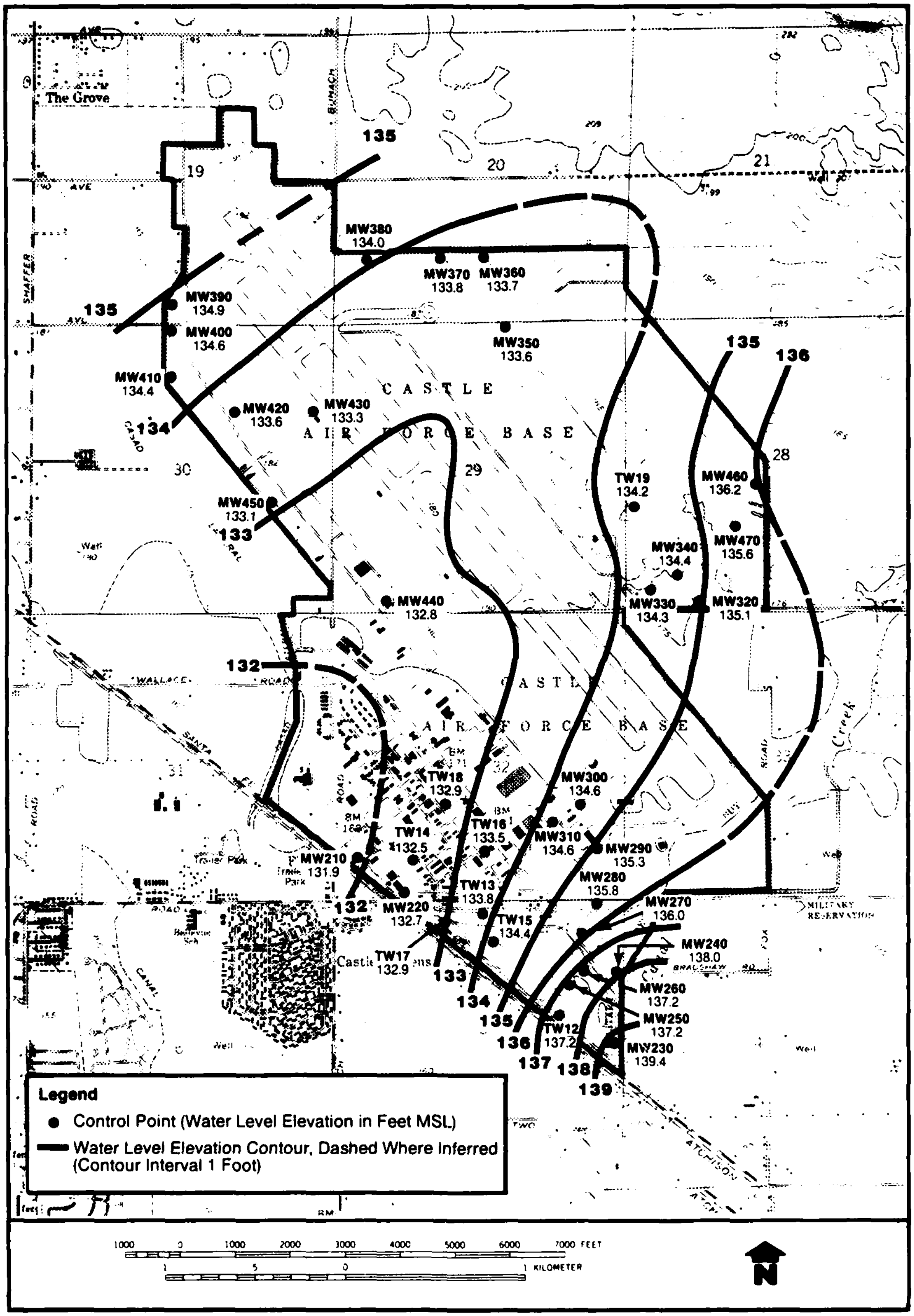


FIGURE 4-5 GROUNDWATER LEVEL MAP FOR THE SHALLOW AQUIFER, 18-19 DECEMBER 1984

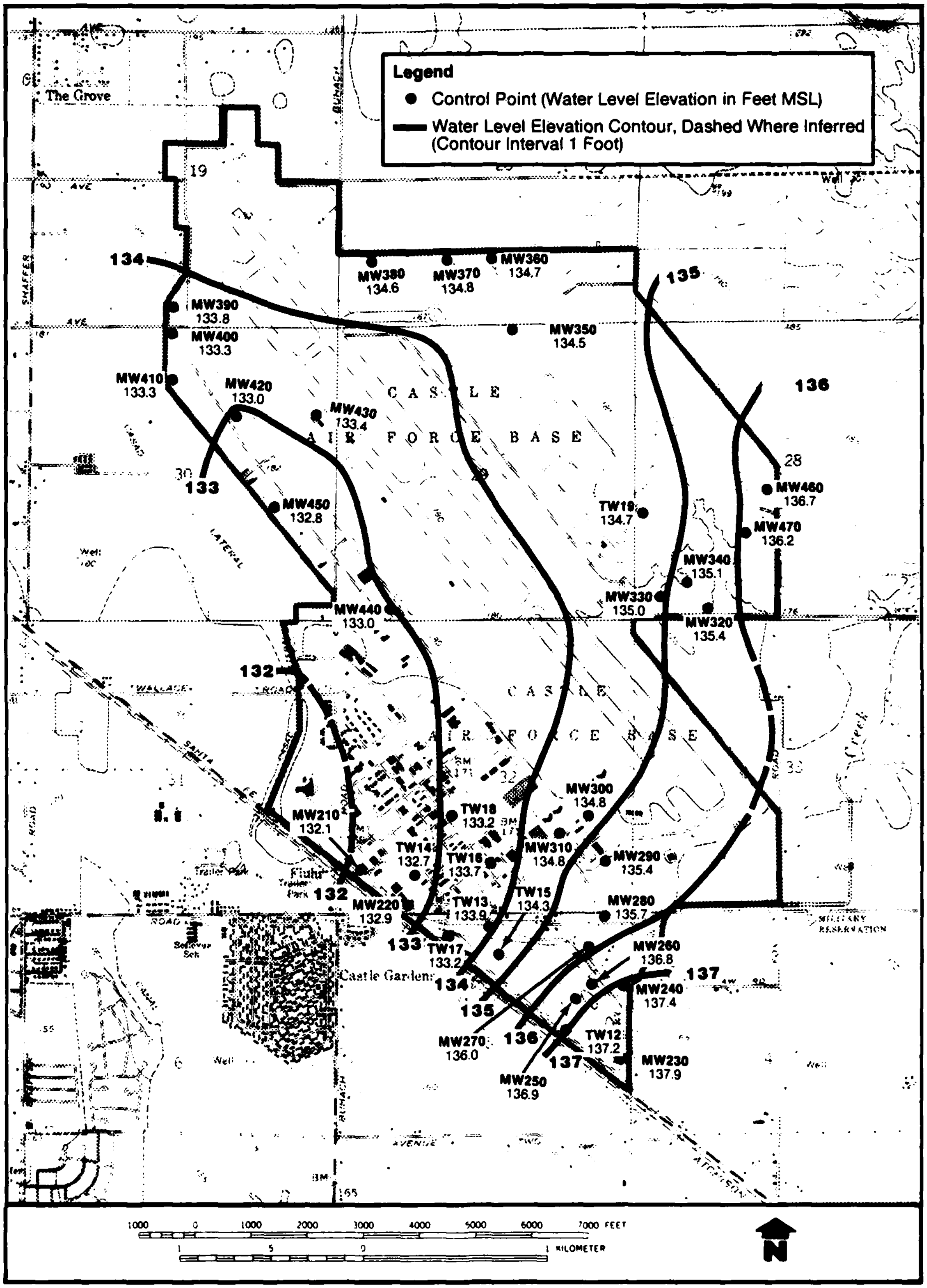


FIGURE 4-6 GROUNDWATER LEVEL MAP FOR THE SHALLOW AQUIFER, 10-11 APRIL 1985

The velocity of groundwater flow is determined by the permeability and porosity of aquifer materials, as well as the hydraulic gradient in the aquifer. The hydraulic gradient, defined as the rate of change in hydraulic head over a given distance of flow, is the driving force which causes groundwater to flow through subsurface materials. The lowest horizontal hydraulic gradients at CAFB, on the order of 0.004, are found in the North and West Flightline Sectors. The highest horizontal gradients, on the order of 0.020, are found in the South Sector, and may be influenced by both spray irrigation of the LF-1 area and leakage from canals adjacent to the Base boundary.

A rough estimate of flow velocity in the Main Base area can be obtained using Darcy's equation and some general assumptions concerning aquifer permeability and porosity. The equation for horizontal flow velocity, v, can be written:

$$v = Ki/n$$

where K = horizontal hydraulic conductivity (a measure of permeability) in feet/day

i = hydraulic gradient, dimensionless

n = effective porosity, dimensionless

Reasonable estimates of horizontal conductivity and porosity for clean sands and gravels are available in standard hydrogeology texts (Davis and Dewiest, 1966; Todd, 1980). Values chosen for the shallow aquifer beneath the Main Base Sector are 2,000 feet per day for hydraulic conductivity, and 0.30 for effective porosity. The hydraulic gradient beneath the Main Base, taken from Figure 4-5, is approximately 0.006. Therefore, the groundwater flow velocity in the shallow aquifer in the exit area for the Base is estimated at 40 feet per day. This is a relatively high velocity for groundwater flow, and would have a significant impact on the rate of contaminant migration from a site, by increasing both the rate of transport and the degree of dispersion in the shallow aquifer.

4.2.4 Sector-Specific Groundwater Conditions

This subsection reviews aquifer materials and flow directions in the shallow aquifer on a sector-specific basis. Figures accompanying the discussion illustrate groundwater levels measured on 18 and 19 December 1984. Areawide data available in Figure 4-5 were incorporated into the sector-specific groundwater flow analyses presented in Figures 4-7 through 4-11.

4.2.4.1 Main Base Sector

The subsurface geology in the Main Base Sector has been extensively described based on available logs from production wells and pilot holes (Subsection 2.4.1). The well logs for the existing test wells (Appendix D-3), for the five new monitor wells drilled in the Main Base Sector (MW-210, MW-220, MW-290, MW-300, and MW-310), and for shallow auger boring (L-310) provide additional detail on the shallow aquifer. In the Main Base Sector, the shallow aquifer consists of 20 to 40 feet of gravel overlain by coarse sand, and was shown to overlie clay in all wells except TW-18, which was finished in coarse sand just below the gravel. Unsaturated sediments overlying the shallow aquifer consist, in general, of silty sand, with 10 to 20 feet of clay reported in MW-220, TW-14, TW-18, MW-300, and up to 34 feet of olive-green plastic clay in MW-290 and MW-310. Approximately 6 feet of iron-cemented sandy hardpan were encountered in MW-210 and MW-220 between depths of 5 and 15 feet.

A groundwater level map for the Main Base Sector has been drawn from the 18 and 19 December 1984 water levels (Figure 4-7). According to this map, flow beneath the Main Base Sector is generally to the northwest, although it probably becomes more westerly beneath the boundary corner between the Base Hospital and the Main Gate. The new monitor wells, MW-290, MW-300, and MW-310, are appropriately placed to monitor groundwater flow in the shallow aquifer in the vicinity of DA-8, although the aquifer is partially confined beneath this area.

Underflow across a portion of the Base boundary is adequately monitored by MW-210, MW-220, and TW-13, but additional monitor wells would be required to monitor the rest of the southwestern boundary where underflow occurs in the vicinity and north of the Base Hospital.

Legend

- ● Control Point (Water Level Elevation in Feet MSL)
- ▬▬ Water Level Elevation Contour, Dashed Where Inferred (Contour Interval 1 Foot)
- ⟵ Groundwater Flow Direction in Shallow Aquifer

Scale in Feet

400 0 400 800 1200

Note: Contour lines and data from figure 4-5 have been incorporated into the flow analysis presented in this figure.

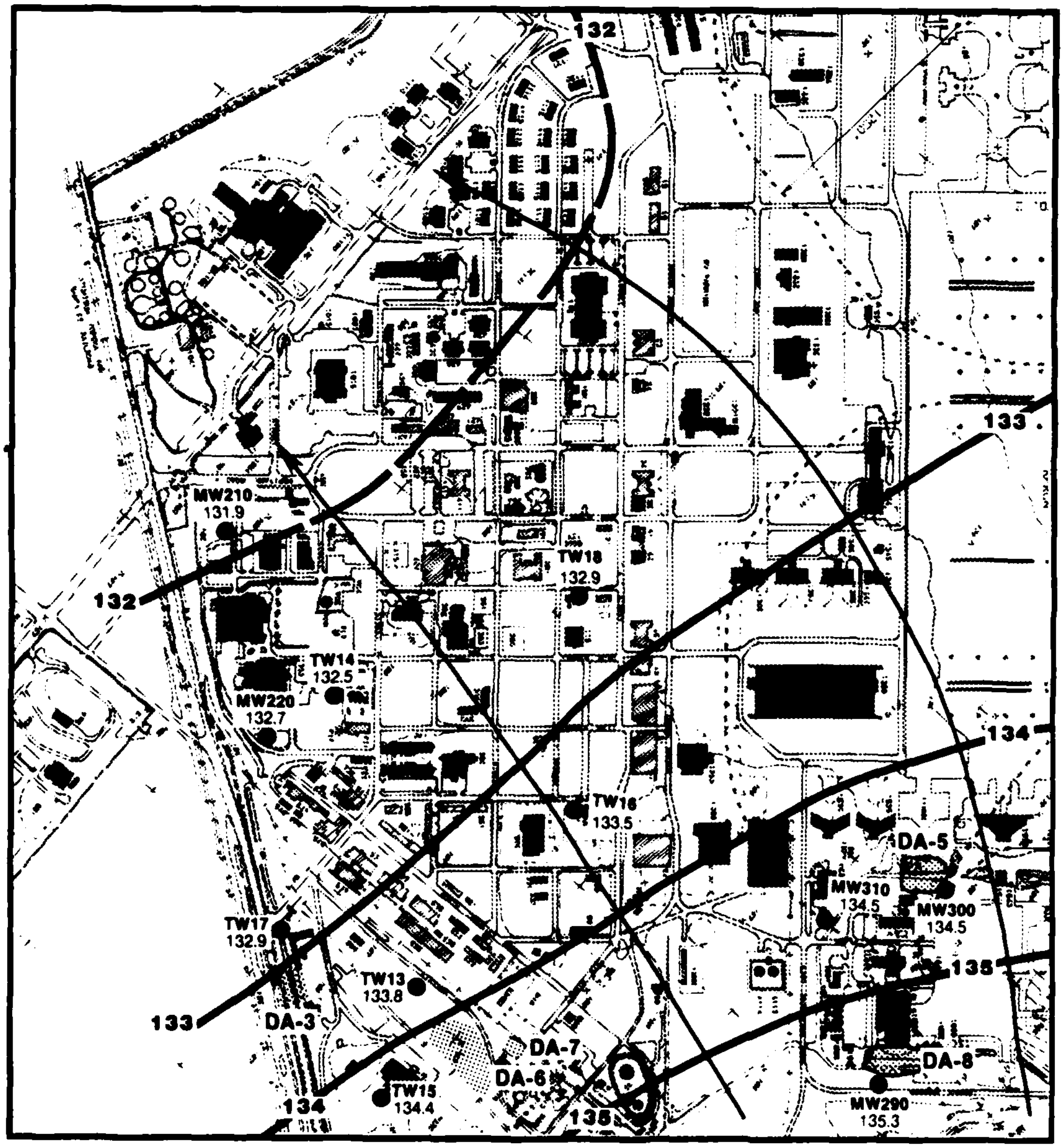


FIGURE 4-7 MAIN BASE SECTOR GROUNDWATER FLOW MAP 18-19 DECEMBER 1984

Static water levels were also measured in deeper wells which were accessible in December. Static water level elevations in PW-3 (average: 131 feet MSL), PW-9 (133 feet), and even in the deep new production well (132 feet) were all close to the elevation measured in the shallow aquifer, indicating that there is little vertical hydraulic gradient, or driving force for groundwater to move upward or downward between aquifers.

4.2.4.2 South Sector

Information on the subsurface geology in the South Sector is available from well logs for TW-12 and the new monitor wells, MW-230, MW-240, MW-250, MW-260, MW-270, and MW-280. In addition, four shallow auger borings were performed at the site of DA-1 east of the Jet Engine Test Cell, and three auger borings (of which only two were finished as lysimeters) were drilled next to MW-230, MW-250, and MW-260. The shallow aquifer in the South Sector consists of interlayered coarse sand and gravel, grading southward to mostly sand. It is underlain by tan, brown, or olive-green clay below depths of 90 to 100 feet. It is overlain by some clay, generally interlayered with sand, in most wells. Shallow unsaturated sediments consist of sand, silty sand, and some clay, including intermittent iron-cemented hardpan occurring discontinuously between depths of 3 and 10 feet. The depth to water in wells ranges from 26 to 34 feet below ground surface.

The water level map for 18 and 19 December 1984 (Figure 4-8) indicates that groundwater flow in the South Sector is primarily to the northwest, with a small component flowing off-Base to the west. There is obvious mounding occurring beneath the area of the spray irrigation field in LF-1. High groundwater levels in the area may also be influenced by leakage from surface water channels converging on the southern corner of the Base, including on-Base perimeter ditches, Canal Creek, and the Livingston Canal. The bottoms of these channels occur at elevations between 150 and 165 feet MSL, or 10 to 25 feet above the water table in an area where the shallow aquifer is only partially confined.

Based on Figure 4-8, the new monitor wells are appropriately located to monitor groundwater flow around the South Landfill Zone, including DA-1, LF-1, LF-2, and associated disposal pits.

Legend

- ● Control Point (Water Level Elevation in Feet MSL)
- ▬▬ Water Level Elevation Contour, Dashed Where Inferred (Contour Interval 1 Foot)
- ◄── Groundwater Flow Direction in Shallow Aquifer

Scale in Feet

400 0 400 800 1200

Note: Contour lines and data from figure 4-5 have been incorporated into the flow analysis presented in this figure.

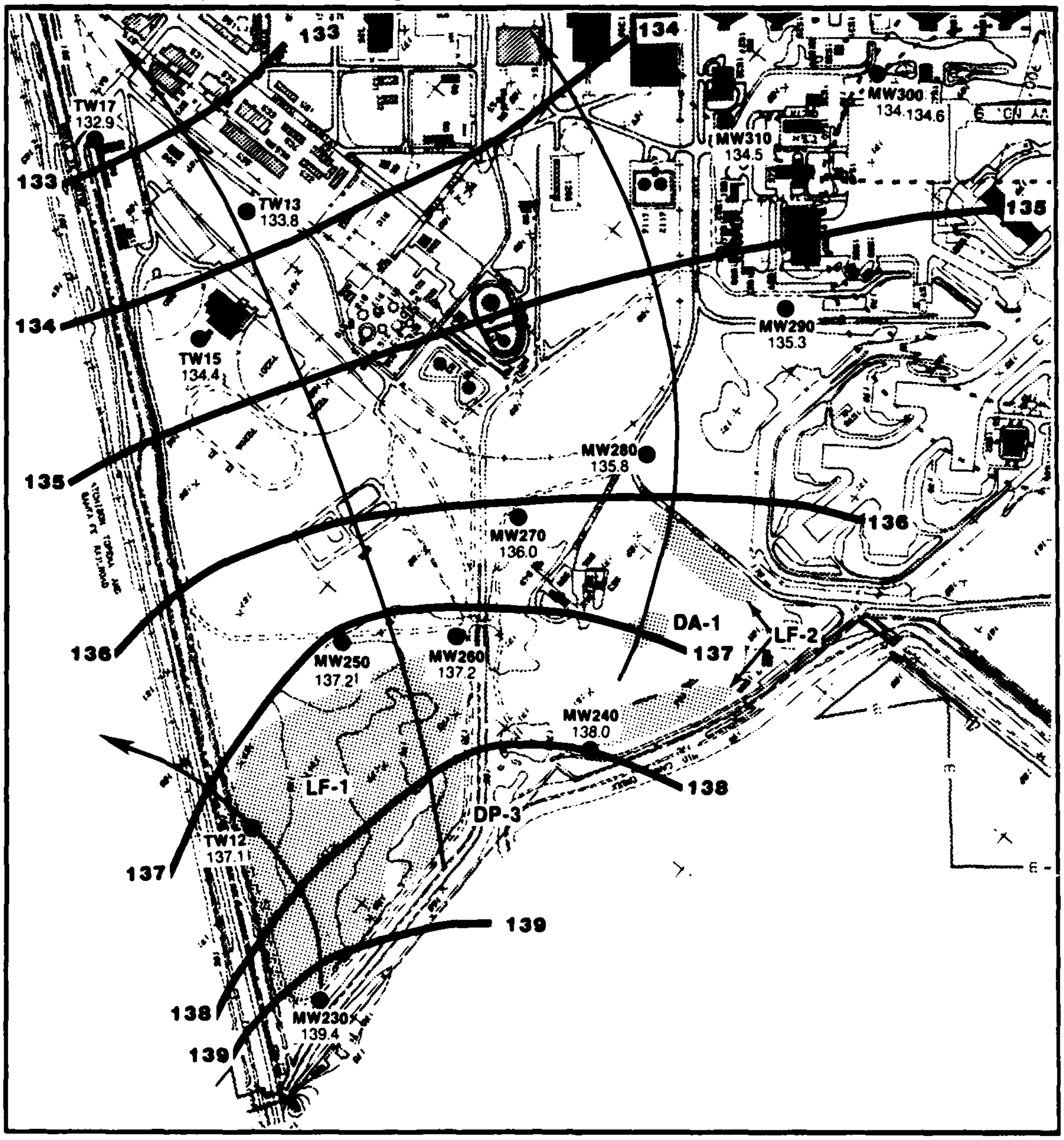


FIGURE 4-8 SOUTH SECTOR GROUNDWATER FLOW MAP, 18-19 DECEMBER 1984

4.2.4.3 East Sector

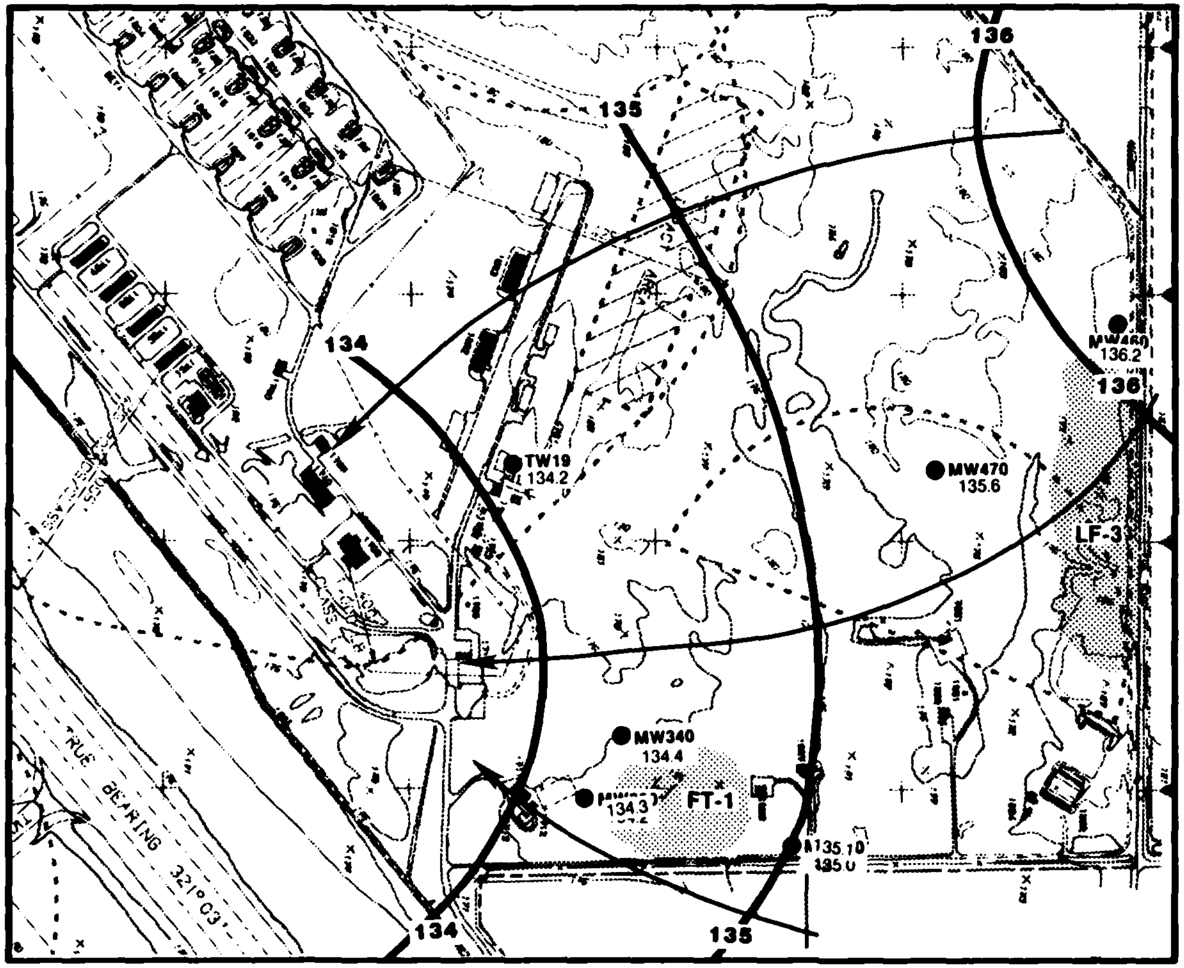
Information on the subsurface geology in the East Sector is available from well logs for PW-5 (Figure 2-6) and for the new monitor wells, MW-320, MW-330, MW-340, MW-460, and MW-470, and from auger borings for lysimeters L-330 and L-340. Subsurface lithology in PW-5, MW-320, and MW-330 consists of finely inter-layered sands, silts, and clays. A bed of coarse varigated sand with occasional clay interlayers corresponding to the shallow aquifer zone can be distinguished between depths of 28 and 84 feet in MW-340 and 58 and 102 feet in MW-470. It is overlain by clay in both boreholes. Shallow unsaturated sediments consist of interlayered sands, silts, and clays, with hardpan en-countered above 10 feet in all boreholes.

The water-level map for 18 and 19 December 1984 (Figure 4-9) indicates that flow is to the west and southwest across the sector. MW-320, MW-330, and MW-340 are appropriately located to monitor groundwater flow around FT-1, and may also monitor groundwater affected by LF-3. LF-3 is only partially monitored by MW-460 and MW-470. However, production well PW-11 completes the downgradient monitoring network for LF-3.

4.2.4.4 North Sector

Information on the subsurface geology in the North Sector is available from well logs for the new monitor wells, MW-350, MW-360, MW-370, and MW-380, and from auger borings for L-360 (not finished as a lysimeter) and L-380. A sand bed consisting of fine to coarse sand, corresponding to the shallow aquifer, can be distinguished in the logs for MW-360, MW-370, and MW-380, between depths of 60 and 95 feet. It is generally overlain by unsaturated sediments consisting of interlayered clays, silts, and sands. Somewhat unexpectedly, a very homogeneous medium to coarse white calcareous sand was encountered in MW-350 from 13 to 113 feet below ground surface. It is overlain by dark grey silty sand with a 5-foot sand interbed.

Groundwater levels for 18 and 19 December 1984 (Figure 4-10) indicate that the North Sector is located on the axis of the trough in the piezometric surface that has been shown to trend northeast and southwest across the area of CAFB. Hydraulic gradients in this sector are very low. Groundwater flow pat-terns tend to converge from the southeast, northeast, and north toward the southwest. Boundary monitor wells MW-360, MW-370, and MW-380, intended as downgradient wells, are in fact located upgradient of the NLFZ, which includes LF-5 and associated disposal pits. In light of this new water-level information, at least two more monitor wells, located between LF-5 and the runway, would be necessary to complete the downgradient monitor well network around this site.



Scale in Feet

400 0 400 800 1200

Legend

● Control Point (Water Level Elevation in Feet MSL)

▬ Water Level Elevation Contour, Dashed Where Inferred (Contour Interval 1 Foot)

← Groundwater Flow Direction in Shallow Aquifer

Note: Contour lines and data from figure 4-5 have been incorporated into the flow analysis presented in this figure.

FIGURE 4-9 EAST SECTOR GROUNDWATER FLOW MAP, 18-19 DECEMBER 1984

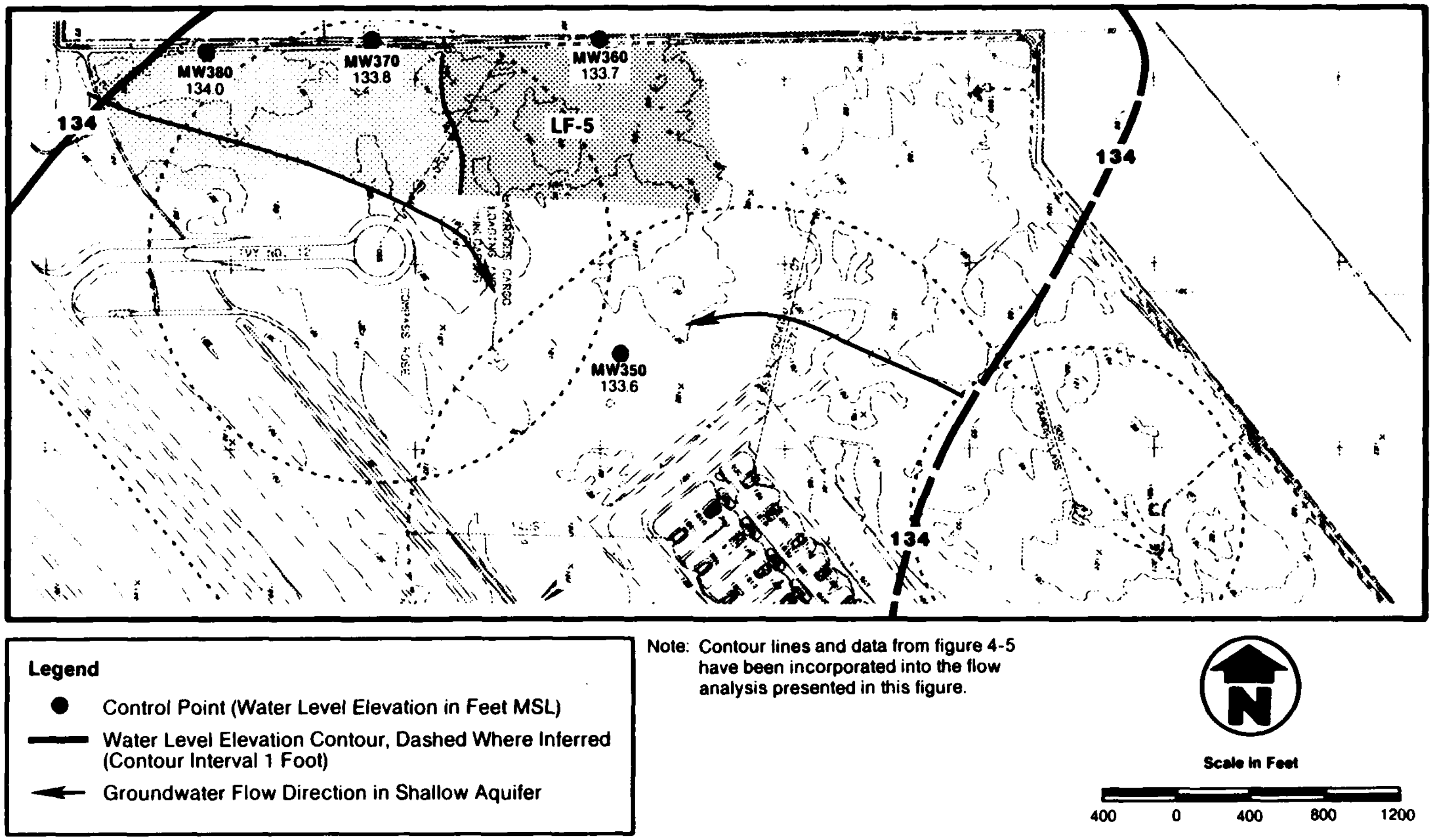


FIGURE 4-10 NORTH SECTOR GROUNDWATER FLOW MAP, 18-19 DECEMBER 1984

4.2.4.5 West Flightline Sector

Information on the subsurface geology in the West Flightline Sector is available from well logs for the new monitor wells, MW-390, MW-400, MW-410, MW-420, MW-430, MW-440, and MW-450, from two shallow auger borings just west of DA-4, and from the auger boring for L-450. Some of this information has been summarized in cross-section AA-AA' in Figure 4-1. The shallow aquifer is the northernmost part of the West Flightline Sector consists of gravel interlayered with coarse sand and locally with clay, grading to the south into a bed of medium sand 15 to 20 feet which is overlain by 15 to 35 feet of clay. Shallow unsaturated sediments consist of interlayered silty sand, sand, and silty clay, with localized and discontinuous hardpan occurring between 5 and 20 feet.

Groundwater levels for 18 and 19 December 1984 (Figure 4-11) indicate that in winter groundwater flow beneath the West Flightline Sector is primarily to the south-southeast in the northern part of the sector, and to the south-southwest in the southern part. As indicated in Subsection 4.4.3, groundwater flow in the spring appears to be influenced by off-Base pumping. Flow from the area of the WLFZ in spring would be primarily to the west-southwest, and flow in the rest of the sector would be primarily to the south, so that flow across the Base boundary from the West Flightline Sector could be expected, at least seasonally. Due to the unexpected direction and variability of groundwater flow patterns in this sector, the existing network of new monitor wells does not adequately monitor the sites in this area. Two additional downgradient wells at the WLFZ and additional wells, one each south of FT-3, DA-2, and FS1-4 would be necessary to complete the monitoring network in this sector. Additional monitor wells should be considered for sites such as DA-4, for which none were proposed in Stage 1, depending on the results of chemical analyses.

4.2.5 Summary

As a result of new geologic and water level data generated from this investigation, a detailed picture of subsurface geology and groundwater conditions in the shallow aquifer has been generated for the area of CAFB. It has been determined from this study that CAFB overlies a highly-permeable shallow sand and gravel aquifer which dips and thickens to the southwest, and is partially confined beneath a discontinuous shallow clay layer. The presence of a trough in the piezometric surface for this aquifer causes flow in the aquifer to converge from the southeast, northeast, and north toward the Main Base and West Flightline Sectors. As a result of the unexpected flow directions

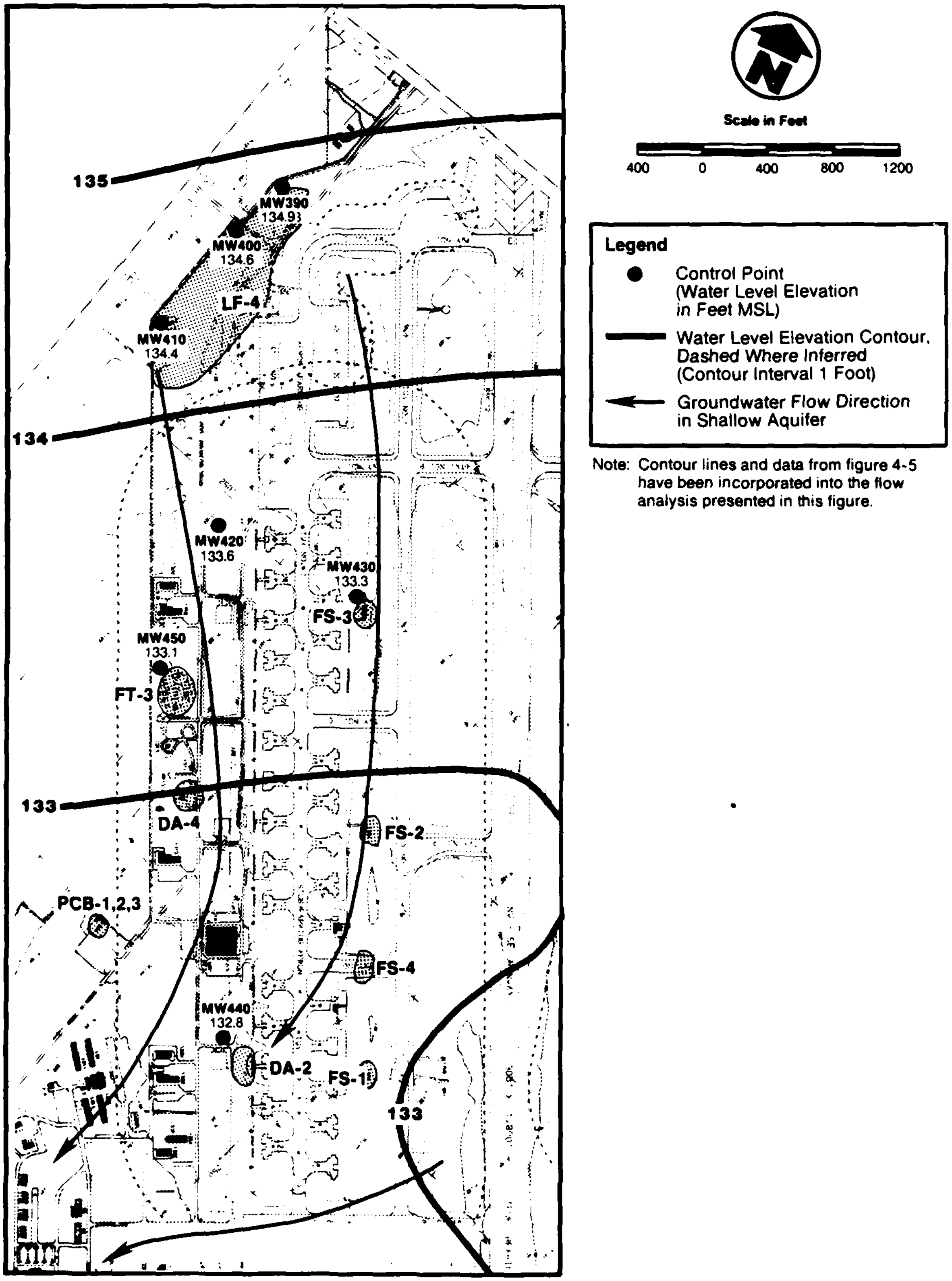


FIGURE 4-11 WEST FLIGHTLINE GROUNDWATER FLOW MAP, 18-19 DECEMBER 1984

encountered in the East, North, and West Flightline Sectors, groundwater monitoring networks around some sites in these sectors are incomplete. It is estimated that at least seven additional wells would be required to complete a Stage 1 confirmation stage monitoring network in the shallow aquifer for all of the sites investigated.

4.3 RESULTS OF PILOT TEST OPERATIONS AT PW-3

The pilot test operations performed on PW-3 (as described in Subsection 3.2.9) yielded valuable information on Main Base hydrogeology, including aquifer parameters and degree of hydraulic connection between the shallow and confined aquifer, and water quality conditions in the two aquifers.

Prior to well reconstruction, PW-3 was test pumped for 24 hours at an estimated rate of 400 to 500 gpm. Water levels were monitored during that period in both PW-3 and TW-14, a test well finished in the shallow aquifer approximately 50 feet away from PW-3. At the end of the period, three well volumes were purged from TW-14 and were collected from both wells and analyzed for VOA. Although accurate depth-to-water measurements could not be made in PW-3 using the airline, a rough measurement of drawdown was estimated. After 24 hours of pumping, the drawdown in PW-3 was approximately 35 feet. The water level in PW-3 recovered 95 percent of the original level within 2 hours of turning the pump off. During the period that PW-3 was pumping, the water level in TW-14 fell only 0.22 feet. During the next 24 hours, it fell another 0.04 feet, then recovered only 0.07 feet overnight. This suggests that the test was performed during a period of naturally-declining water levels in the shallow aquifer, and that pumping from PW-3 had no significant effect on water levels in the area of the shallow aquifer immediately overlying the production well intake. In this area, the shallow and confined aquifers can be considered hydraulically separate, and any leakage between the two aquifers would have to be at a relatively slow rate.

Results of the VOA analyses performed on the two samples collected from TW-14 and PW-3 at the end of the initial pumping test on 14 November can be compared in Table 4-1, where they are designated as TW-14-1 and PW-3-1, respectively. Table 4-1 also summarizes the results of all other VOA analyses which were performed on samples from PW-3 during this investigation. Of the 32 priority pollutant VOA compounds plus methyl ethyl ketone (MEK) analyzed, only those which were actually detected in at least one sample have been reported in Table 4-1.

Table 4-1

Summary of Groundwater Analyses Results for VOA Compounds, PW-3 Pilot Test Samples

Sample	Detection Limit (mg/l)	TW-14-1	PW-3-1	PW-3-2	PW-3-3	PW-3-4	PW-3-5	PW-3-6	PW-3-7	PW-3-8	PW-3-9
Date sampled		14 Nov 84	14 Nov 84	19 Nov 84	19 Nov 84	19 Nov 84	19 Nov 84	17 Jan 85	17 Jan 85	17 Jan 85	18 Jan 85
Time sampled									1937	2233	0745
Sample method		Pumped	Pumped	Bailed	Bailed	Bailed	Bailed	Bailed	Pumped	Pumped	Pumped
Sample depth (feet)				50	170	230	273	281			
1,1-Dichloroethene	0.0002	ND	0.0010	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,2-dichloroethene	0.0001	0.0072	0.0011	0.0014	0.0016	0.0013	0.0013	0.0008	0.0008	0.0010	0.0013
Chloroform	0.0001	0.0031	0.0006	0.0002	0.0003	0.0002	0.0002	0.0003	0.0001	0.0002	0.0002
1,2-dichloroethane	0.00002	ND	ND	ND	ND	ND	ND	0.00005	0.00004	0.00003	ND
1,1,1-trichloroethane	0.0001	0.0002	0.0004	0.0013	0.0024	0.0003	0.0006	0.0010	0.0003	ND	ND
Carbon tetrachloride	0.0001	0.0003	9.0006	ND	ND	0.0002	0.0005	0.0008	0.0006	0.0008	0.0009
Bromodichloromethane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0002
1,2-dichloropropane	0.0001	ND	ND	ND	ND	ND	ND	0.0001	ND	0.0001	ND
Trichloroethylene	0.0001	0.260	0.044	0.017	0.043	0.018	0.043	0.0067	0.014	0.011	0.013
Tetrachloroethene	0.00005	0.0003	0.0001	0.0004	0.0004	ND	0.0005	0.0001	0.0001	0.0001	0.0001
1,4-dichlorobenzene	0.0002	ND	ND	ND	ND	ND	ND	0.0004	0.0005	0.0004	0.0004
Toluene	0.0002	ND	ND	ND	0.660	ND	ND	ND	0.0007	0.0009	0.0016
Ethylbenzene	0.0002	ND	ND	ND	ND	ND	ND	ND	0.0005	ND	ND

Notes: ND = None detected.
-- = Analysis not requested.

Table 4-1
(continued)

Sample	PW-3	PW-3-10	PW-3-11	PW-3-12	PW-3-13	PW-31	PW-32	PW-33	PW-34	PW-3
Date sampled	22 Jan 85	25 Jan 85	01 Feb 85	11 Feb 85	18 Feb 85	18 Feb 85	18 Feb 85	18 Feb 85	18 Feb 85	09 Apr 85
Time sampled	0715	0730								
Sample method	Pumped	Pumped	Pumped	Pumped	Pumped	Pumped	Pumped	Pumped	Pumped	Pumped
Sample depth (feet)										
1,1-Dichloroethene	ND	ND	ND	ND	ND	--	--	--	--	ND
Trans-1,2-dichloroethene	0.0014	0.0009	0.0006	ND	ND	--	--	--	--	ND
Chloroform	ND	ND	ND	ND	ND	--	--	--	--	ND
1,2-dichloroethane	ND	ND	ND	ND	ND	--	--	--	--	ND
1,1,1-trichloroethane	ND	ND	0.0040	ND	ND	--	--	--	--	0.00026
Carbon tetrachloride	ND	ND	ND	ND	ND	--	--	--	--	ND
Bromodichloromethane	ND	ND	ND	ND	ND	--	--	--	--	ND
1,2-dichloropropane	ND	ND	ND	ND	ND	--	--	--	--	ND
Trichloroethylene	0.025	0.045	0.019	0.0032	0.0074	0.0090	0.0098	0.015	0.011	0.044
Tetrachloroethene	ND	ND	ND	ND	ND	--	--	--	--	ND
1,4-dichlorobenzene	0.0003	ND	ND	ND	ND	--	--	--	--	ND
Toluene	ND	ND	ND	ND	ND	--	--	--	--	ND
Ethylbenzene	ND	0.0049	ND	ND	ND	--	--	--	--	ND

Full laboratory reports are provided in Appendix L. Before reconstruction of PW-3, concentrations of trans-1,2-dichloroethylene, chloroform, and trichloroethylene in PW-3 were 15 to 20 percent the concentration found in TW-14, and tetrachloroethylene was almost 50 percent. The following compounds were found at higher concentrations in PW-3 than in TW-14: 1,1-dichloroethene, 1,1,1-trichloroethane, and carbon tetrachloride. The only compounds consistently found in PW-3 at concentrations greater than 0.002 mg/L was trichloroethylene (TCE).

On 19 November, an attempt was made to use a point source Teflon bailer to collect samples from discrete depths in order to test for zones of casing leakage. In these samples, TCE was found to vary between 0.017 and 0.043 mg/L, but no clear correlation with depth was observed. No further samples were collected until PW-3 had been reconstructed following the procedures described in Subsection 3.2.9.

Upon completion of well reconstruction, a submersible pump was used to test pump PW-3 for 2 hours at a rate of approximately 420 gpm on 11 January 1985. At the start of the test, the static water level elevation in TW-14 was 0.52 higher than the static water level elevation in PW-3. After the start of testing, the drawdown in PW-3 stabilized at approximately 11 feet within less than 1/2 hour and remained the same for the rest of the test. After 1/2 hour of pumping, the water level in TW-14 had risen slightly (0.04 feet) and did not appear to be affected by pumping from PW-3. Recovery measurements were made on the water level in PW-3 after the end of pumping and by standard recovery test methods (Appendix E). A value of transmissivity of 8,700 ft^2/day for the confined aquifer in the vicinity of PW-3 was calculated from the test data.

Upon completion of well development and testing on 14 January 1985, a sample was bailed from the bottom of PW-3 and was found to contain TCE at a concentration of 0.0067 mg/L. The turbine pump was reinstalled in PW-3 on 16 January, and a 4-week test pumping and sampling program was begun on 17 January. Results of VOA analyses for the samples collected during this period (PW-3-7 through PW-3-13) are summarized in Table 4-1.

At the end of the test period, TCE was the only VOA compound detected in samples from PW-3. Replicates taken on 18 February 1985 indicated that TCE concentrations in the confined aquifer in the vicinity of PW-3 ranged between 0.0079 and 0.015 mg/L, and averaged approximately 0.010 mg/L.

In Figure 4-12, TCE concentrations measured in PW-3 during the 4-week test period have been plotted against volume pumped since the beginning of the test. The plot shows that TCE concentrations in pumped water rose sharply during the early part of the test, then began to taper off after the first 10 million gallons of pumpage. This is interpreted to mean that the early, relatively low concentrations measured at the beginning of the test resulted from the introduction of fluids (potable water and bentonite and cement slurries) during well reconstruction, resulting in dilution of TCE in the immediate vicinity of the well intake. The peak concentration of 0.045 mg/L reached after approximately 10 million gallons of pumpage corresponds to the highest levels of contamination found in the vicinity of the well prior to reconstruction. The lower levels attained at the end of the test are interpreted to represent the concentration of TCE which would be found in water from PW-3 if long-term pumping was resumed in the well. In this situation, a "dynamic equilibrium" is reached in which water drawn from portions of the aquifer at some distance from the pumping well mixes with and dilutes contaminated water in the immediate vicinity of the well.

On 25 February 1985, the pump in PW-3 was turned off, and the well was left static for approximately 1-1/2 months. On 9 April 1985, during the second round of water sampling, the pump was turned on and approximately 26,000 gallons (17 well volumes) were pumped from the well before it was sampled. Analytical results for this last PW-3 sample are reported in the last column in Table 4-1. Except for a trace (0.00026 mg/L) of 1,1,1-trichloroethane, the only VOA compound detected was TCE at a concentration of 0.044 mg/L. This result indicates that the new "static equilibrium" is very similar to the one which existed before well reconstruction. Under static conditions, groundwater in the vicinity of the PW-3 intake has a concentration between 0.040 and 0.045 mg/L. Groundwater sampled during the same period from TW-14 had a TCE concentration of 0.280 mg/L, close to the level measured before well reconstruction.

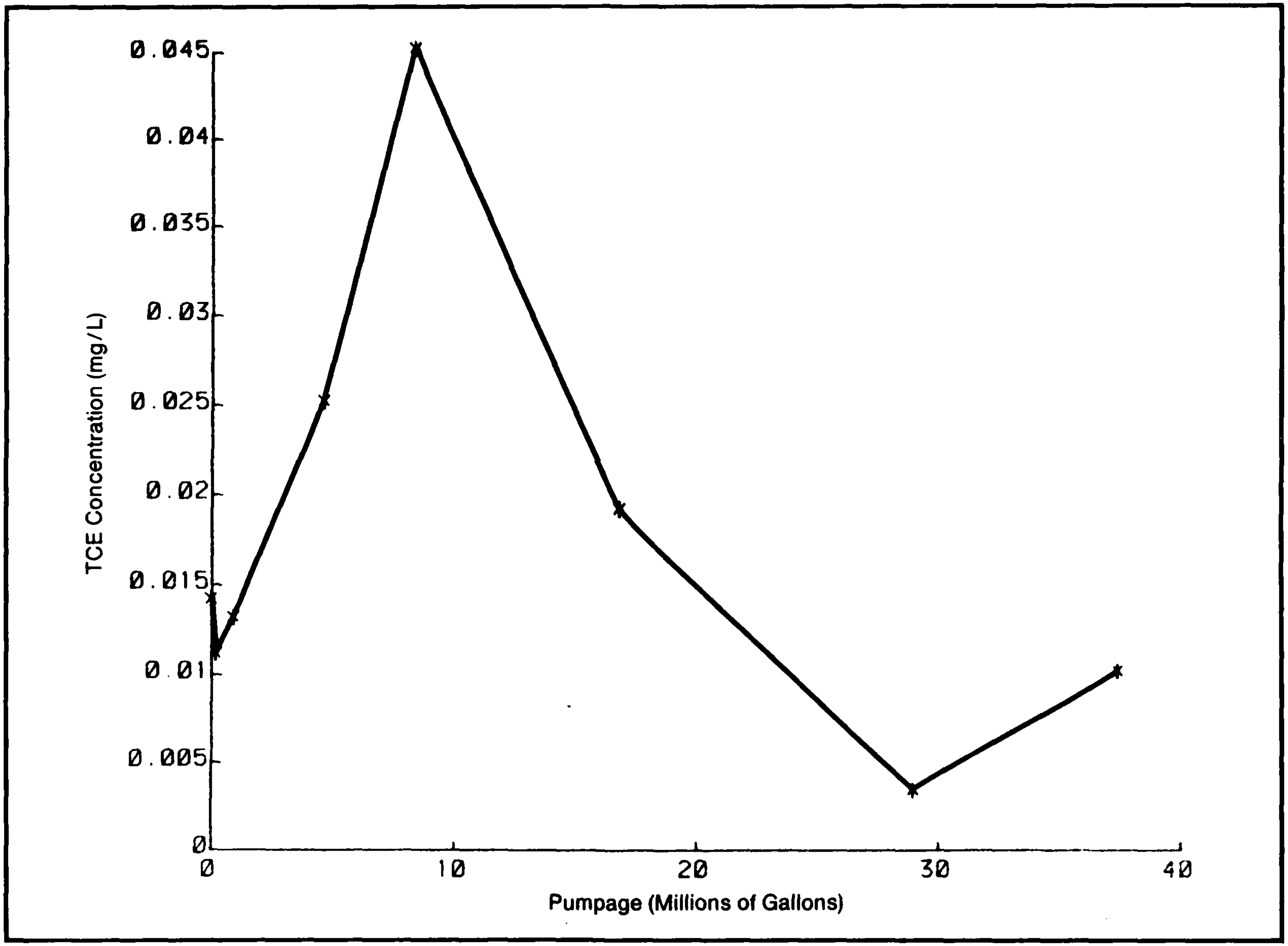


FIGURE 4-12 GRAPH OF TCE CONCENTRATIONS IN PW-3 DURING FOUR-WEEK TEST PERIOD

It is concluded that the well reconstruction has not had a significant effect on the level of contamination found in the confined aquifer in the immediate vicinity of PW-3 under static conditions. It is not known whether this is because downcasing leakage was not effectively sealed off or because contamination in the confined aquifer is actually more extensive than has been assumed to date. Concentrations of TCE in pumped water from PW-3 under long-term pumping conditions have been shown to stabilize around 0.010 mg/L (an improvement over pre-reconstruction conditions), but they still remain above the California action level for TCE of 0.005 mg/L. Further investigation (as outlined in Sections 5 and 6) will be required to more accurately define the extent of TCE contamination in the confined aquifer in the Main Base Sector.

4.4 RESULTS OF GEOPHYSICAL SURVEYS

Methodologies for magnetometer and ground penetrating radar (GPR) surveys conducted at three sites (DA-8, DP-3, and LF-5) were described in Subsection 3.3.4. This section reviews the results of the geophysical surveys for each site individually in terms of the objective(s) for that site. These results have been combined with an evaluation of soil and water quality data to develop site-specific conclusions and recommendations described in Subsection 4.8 and Section 6.

4.4.1 Main Base Sector: DA-8

The combined results of the geophysical surveys at DA-8 have been illustrated in Figure 4-13. The objective of the survey was to identify a subsurface pipe which might connect Building 1550 to the drainage ditch. Eight buried pipes or segments of pipes were identified in the survey, two of which could be visually confirmed as buried utilities. Pipe A is an 8-inch clay storm sewer line, buried 6 feet deep and running parallel to the side of the building. According to Base utility plans, buried water and fuel lines also parallel pipe A. Pipe G is a partially buried steel storm sewer culvert.

Of the pipes which could not be visually confirmed, pipe B is a relatively large diameter (greater than 6-inch) line and appears to correspond to a fuel line spur serving as a pump-out line, shown schematically on the Base utilities plan. According to these plans, water and steam pipes also parallel this line, but individual pipes could not be distinguished in the GPR profiles.

Pipes C, D, D', E, and F had similar GPR signatures: all appear to be relatively small-diameter (less than 6-inch) pipes buried at shallow depths (less than 6 feet). All are good GPR reflectors, implying they are metal pipes or cables. Of these, F may correspond to an underground telephone cable shown schematically on Base utility plans as crossing the parking lot at an angle to the side of the building. Pipes C, D, D', and E do not correspond to known utilities, and could require further investigation if they cannot be identified by Base shop personnel.

4.4.2 South Sector: DP-3

Results of the GPR and magnetometer surveys at DP-3 in the South Landfill Zone are illustrated in Figures 4-14 and 4-15, respectively. The objectives of the geophysical surveys were to outline the areal extent of fill material and determine the presence or absence of buried drums.

Four areas of disturbed subsoils were identified from the GPR survey (Figure 4-14). These areas correspond closely to zones of magnetic anomaly depicted in Figure 4-15. A fifth zone of magnetic anomaly, slightly west of the other four zones, can also be distinguished in Figure 4-15. All five zones fall within or near the edges of the borrow pit identified in tne 1952-1954 Base topographic plan. In addition, five individual high priority (drum-like) targets were identified in the GPR profiles. These targets correspond closely to two areas of disturbed subsoil and magnetic anomaly, and are near the deepest of the old borrow pits.

The results of the geophysical surveys at DP-3 have confirmed the existence of fill material and possibly a few buried drums at the site of an old borrow pit in the South Landfill Zone. These results would be most useful in directing future excavation efforts for site cleanup should they be warranted on the basis of groundwater monitoring results at the site.

4.4.3 North Sector: LF-5

Figures 4-16 and 4-17 illustrate the results of the GPR and magnetometer surveys, respectively at LF-5 in the North Landfill Zone. The objectives of the geophysical surveys were to outline the extent of fill material and determine the presence or absence of buried drums.

A review of aerial photographs and field observations were used prior to the survey to outline trenches and other areas of landfilling activity, such as scraped areas and bulldozed mounds. Two open pits were identified: pit A at the end of Trench B, in which numerous (10 to 20) crushed metal drums were observed in the side of the pit and excavated material; and pit B, an open pit with various construction debris (concrete blocks, signposts, wood and metal crushed drums, and various other debris which were also observed on the far east face of mound A. No whole or closed drums were observed. Two sets of trenches can be distinguished: the trenches on the west side of the area surveyed are generally about 250 feet long and trend east-west. Trenches on the east side tend to be longer (300 to 600 feet) and usually trend north-south. The GPR survey concentrated on 11 trenches (labeled A through K). A twelfth trench (L) was identified after completion of the GPR survey. The magnetometer survey was conducted on all the trenches (A though L) and on adjacent areas including mounds A and B. In general, magnetometer results provided good confirmation of the trench boundaries since they had been defined visually from surface evidence.

Of the eastern trenches (A through F), trench B exhibited the strongest evidence for buried drums, including two high magnetic anomalies near the center and southeast end of the trench, and drum-like signatures on the GPR profile at the southeast end adjacent to drum pit A. In addition, some individual targets were found on GPR profiles for the center and northwest half of the trench; these targets displayed signatures similar to drum signatures. Trench D, on its southern end, exhibited the second-highest concentration of highly-reflective material (probably mixed metal scrap, possibly including drums). Of the remaining four trenches (A, C, E, and F), all four exhibited random areas of magnetic anomaly, concentrations of reflective material, or drum-like targets, in either the magnetometer or GPR surveys, but none exhibited significant concentrations.

Of the western trenches (G through L), two (J and L) exhibited high magnetic anomalies. In association with the magnetic anomaly in trench J, high-priority drum-like targets and concentrations of highly-reflective subsurface material were detected in the GPR survey. Of the remaining western trenches (G, H, I, and K), I and K exhibited no significant evidence of buried metal fill. Five drum-like targets were identified in trench G, and one small area of reflective material in the eastern end of trench H.

Based on these findings, trenches J and B are considered to have the highest likelihood of containing buried metal drums of any of the trenches in LF-5. Other trenches exhibiting evidence of some concentration of buried metal objects included D and L. The other eight trenches are considered to have a relatively low priority compared to these four.

4.5 RESULTS OF CHEMICAL ANALYSES OF SOILS AND SEDIMENTS

This section reviews chemical data obtained from soil and sediment samples collected at CAFB in November 1984. The samples collected included surface and shallow subsurface soils and ditch-bottom sediments. Methods used in sample collection were described in Section 3. Additional detail on field sampling protocols is provided in Appendix G, and laboratory methods used in sample analysis are listed in Appendix K. Laboratory analytical reports for soil and sediment samples are reproduced in Appendix L.1.

4.5.1 Surface and Shallow Subsurface Soil Results

Surface and shallow subsurface soils were collected at three investigation sites: DA-7 in the Main Base Sector; DA-1 in the South Sector; and DA-4 in the West Flightline Sector. Types of samples collected, parameters analyzed, and analytical results are reviewed on a site-by-site basis below.

4.5.1.1 Main Base Sector: DA-7

Two samples composited from six sampling locations were collected at site DA-7, the Entomology Yard, as described in Subsection 3.3.3.5. One sample was split, and a total of three samples were submitted for analysis of six pesticides and herbicides. The six compounds analyzed (and their detection limits in ug/g) were:

endrin	0.02
lindane	0.01
methoxychlor	0.02
toxaphene	1.00
2,4-D	0.06
2,4,5-TP	0.06

None were found above detection limits in any of the three samples analyzed.

4.5.1.2 South Sector: DA-1

A total of 16 samples were collected for immediate analysis of VOA and oil and grease from four boreholes drilled by hollow-stem auger at DA-1, the runoff area just east of the jet engine test cell, as described in Subsection 3.3.3.3. In general, boreholes were drilled in areas of obvious surface soil staining, and samples were collected by split-spoon methods from intervals of 0 to 1.5 feet, 3.5 to 5 feet, and 9 to 10.5 feet.

Due to the volume of sample required for adequate storage, transportation, and analysis, duplicates were collected by re-drilling the top 2 feet of soil next to the original borehole for that sample location. Therefore, variability in duplicate sample results most likely represents heterogeneity in the distribution of the parameters analyzed within very short distances in the surface soil.

Of the 32 priority pollutant VOA compounds plus MEK analyzed, none were detected in any of the 16 samples (Appendix L.1). The oil and grease results for DA-1 are summarized in Table 4-2. Samples from locations 1 and 2 were collected in the topographic depression where the most ponding of runoff would be likely to occur; location 3 was in the runoff channel connecting the jet test cell to this depression; location 4 was directly behind the blast fence for building 953, in an area of obvious runoff (Figure 3-5). In general, the highest concentrations of oil and grease (1,500 to 9,500 ug/g) were found in the 0 to 1.5 foot interval. In most locations, concentrations of oil and grease found in deeper sampling intervals were below 300 ug/g. This pattern was reversed in location 3, where the highest concentration (950 ug/g) was found in the 9 to 10.5 foot interval. This variability in vertical distribution of oil and grease is probably explained by the heterogeneity of the shallow subsurface profile as discussed in Subsection 4.1 of this report and in Appendix D.2. In areas where shallow low-permeability layers such as hardpan or clay are found, hydrocarbon compounds would be expected to be retained in shallow soil horizons. These layers are not laterally continuous, however, and may pinch out within short distances. In localities where they are absent, hydrocarbon compounds would be expected to be carried deeper into the soil profile.

Table 4-2

Summary of DA-1 Soil Analyses Results for Oil and Grease

Sample Location Number	Depth Interval Sampled (feet)	Concentration of Oil and Grease (ug/g)
1	0 - 1.5	1,800
	0 - 1.5 (dup)	9,500
	3.5 - 5	120
	9 - 10.5	120
2	0 - 1.5	8,500
	0 - 1.5 (dup)	7,500
	3.5 - 5	280
	9 - 10.5	150
3	0 - 1.5	180
	0 - 1.5 (dup)	200
	3.5 - 5	250
	9 - 10.5	950
4	0 - 1.5	1,500
	0 - 1.5 (dup)	160
	3.5 - 5	750
	9 - 10.5	100

4.5.1.3 West Flightline Sector: DA-4

A total of eight samples was collected from two boreholes drilled west of the fence behind the Liquid Oxygen Plant (Building 1318), as described in Subsection 3.3.3.3. Samples were collected by split-spoon methods from intervals of 0 to 1 feet, 4 to 5 feet, and 9 to 10 feet for analysis of VOA. Duplicates were collected from the 0 to 1 foot interval in both boreholes. Of the 32 priority pollutant VOA compounds plus MEK, none were detected in any of the eight samples collected from DA-4 (Appendix L.1).

4.5.2 Ditch Sediment Results

Ditch sediment samples were collected from locations adjacent to and downstream from three investigation sites: DA-8, DA-5, and DA-3, all in the Main Base Sector. All locations were sampled by driving a split-spoon twice at the same location, to a total depth between 2 and 3 feet. Samples were collected separately from the 0- to 1- and 1- to 2-foot intervals. Duplicates, when collected, were taken from the upper interval. Parameters analyzed and results obtained are reviewed on a site-by-site basis in the following subsection.

During the investigation, it was noted that the open ditches at CAFB are dredged annually in the fall to remove hydrophilic vegetation which clogs the channels by the end of each summer. In the process, bottom sediment is dredged out and dumped on the sides of the ditches where it is allowed to dry before it is removed or worked into the sides of the channels. Therefore, it is unlikely that any type of contaminant would accumulate in ditch-bottom sediments at CAFB on a long-term basis, and any volatile contaminants would almost certainly be driven off in the dredging process. Ditch-bottom sediments for this investigation were collected just prior to the dredging, and represent primarily sediment accumulated from 1983 to 1984.

4.5.2.1 Main Base Sector: DA-8

A total of seven samples (including one duplicate) was collected for analysis of VOA at DA-8, from three locations adjacent to and downstream from building 1550, as described in Subsection 3.3.3.4. Of the 32 priority pollutant VOA compounds plus MEK, none was detected in any of the seven samples (Appendix L.1).

4.5.2.2 Main Base Sector: DA-5

A total of seven samples (including one duplicate) was collected for analysis of VOA and oil and grease at DA-5, from three locations adjacent to and downstream from the aircraft washrack, as described in Subsection 3.3.3.4.

Of the 32 priority pollutant VOA compounds plus MEK, none was detected in any of the seven samples (Appendix L.1). Oil and grease results for ditch sediment samples from DA-5 are summarized in Table 4-3. Concentrations of oil and grease ranged from 80 to 120 ug/g, and no significant variability was detected which would be correlated with depth or distance from the investigation site.

4.5.2.3 Main Base Sector: DA-3

A total of five samples (including one duplicate) was collected for analysis of VOA, oil and grease, four pesticides (endrin, lindane, methoxychlor, and toxaphene) and two herbicides (2,4-D and 2,4,5-TP) at DA-3, from two locations adjacent to and approximately 100 feet downstream from the CE yard washrack (building 850). A more complete description of sampling locations and methods is provided in Subsection 3.3.3.4.

Of the 32 priority pollutant VOA compounds plus MEK, the four pesticides, and the two herbicides, none was detected above detection limits (Appendix L.1). Oil and grease results for ditch sediment samples from DA-3 are summarized in Table 4-4. At both locations, significant concentrations (1,200 to 2,400 ug/g) of oil and grease were found in the 0- to 1-foot interval, and relatively low levels (80 to 160 ug/g) in the 1- to 2-foot intervals.

4.5.3 Significance of Soil and Sediment Results

Of the analytes sampled in soil and sediment at CAFB, no VOA compounds, herbicides, or pesticides were detected. Results of oil and grease analyses performed on samples from three sites (DA-1, DA-5, and DA-3) have been summarized in Tables 4-2, 4-3, and 4-4. At DA-1 and DA-3, oil and grease concentrations in surface sediments were found to be one order of magnitude higher than deeper sediments from the same sites or sediment from DA-5.

Table 4-3

Summary of DA-5 Ditch Sediment Analyses Results for Oil and Grease

Sample Location Number	Sample Location Description	Depth Interval Sampled (feet)	Concentration of Oil and Grease (ug/g)
1	Adjacent to washrack	0 - 1	100
		0 - 1 (dup)	80
		1 - 2	120
2	300 feet downstream	0 - 1	110
		1 - 2	90
3	600 feet downstream	0 - 1	120
		1 - 2	80

Table 4-4

Summary of DA-3 Ditch Sediment Analyses Results for Oil and Grease

Sample Location Number	Sample Location Description	Depth Interval Sampled (feet)	Concentration of Oil and Grease (ug/g)
1	Adjacent to washrack	0 - 1	1,700
		0 - 1 (dup)	1,200
		1 - 2	80
2	100 feet downstream	0 - 1	2,400
		1 - 2	160

The oil and grease analysis does not quantify a specific compound, but measures groups of substances on the basis of their common solubility in Freon. Therefore, the specific identity of the compounds contributing to a measurement of oil and grease is unknown. Most components and byproducts of petroleum-based products, including aromatics such as toluene and benzene, as well as heavier molecules, are soluble in Freon, and are included in a total oil and grease analysis. All soils analyzed for oil and grease at CAFB were also analyzed for the 32 priority pollutant compounds plus MEK, and none were detected. This indicates that, where petroleum-derived compounds were part of the oil and grease measured, they are most likely heavier, less mobile compounds than the volatile aromatics. Based on this investigation, none of the sites where soils or ditch sediments were sampled at CAFB are considered to warrant further investigation.

4.6 WATER QUALITY RESULTS FOR GROUNDWATER

This subsection reviews chemical data, including results of both field measurements and laboratory analyses, obtained from groundwater samples collected at CAFB between January and April 1985 (exclusive of chemical data related to pilot test operations at PW-3). Samples were collected in two rounds (22 January to 1 February and 1 to 12 April 1985) from new monitor wells and existing test wells screened in the shallow aquifer and from all accessible production wells, including: the new production well (new PW) screened in both the confined and deep aquifer; PW-1, PW-2, PW-3, PW-4 (sampled in the second round only), PW-7, and PW-8 in the confined aquifer; and PW-5, PW-6, and PW-11 in the shallow aquifer. The shallow lysimeters installed in November 1984 could not be sampled because they were dry in both sampling rounds. Methods used in sample collection are described in Section 3 and in the Field Sampling and QA/QC Plan (Appendix G). Laboratory methods used in sample analysis are listed in Appendix K, and laboratory reports are provided in Appendix L. Applicable Federal and State water quality standards are referenced in Appendix M.

All available water quality data from the groundwater investigation have been summarized in Tables 4-5 through 4-22. The data have been arranged by sector, and appropriate tables have been placed with each sector discussion. The VOA table for a sector summarizes the results of the total organic halogen (TOX) and VOA analyses, listing only those parameters that were detected at least once within the set of wells in that sector. The second table for each sector summarizes the results of the field tests (pH and specific conductance) and the laboratory analyses for total organic carbon (TOC), oil and grease, phenols, nitrate, cadmium, chromium, lead, mercury, silver, endrin, lindane, methoxychlor, toxaphene, 2,4-D, and 2,4,5-TP.

Due to the volume of data generated from the groundwater investigation at CAFB, the site-specific data review will be preceded by a discussion of the significance of findings. This discussion will serve to establish the "ground rules" for the subsequent site-by-site evaluation of the groundwater quality data.

4.6.1 Significance of Groundwater Results

The significance of groundwater results at a specific site will be determined primarily from a comparison of those results with natural or background levels for the same compounds, and with Federal or state water quality standards (when they exist) for those compounds. A general data review (Subsections 4.6.1.1 and 4.6.1.2) will serve to establish background levels for each analyte in the analytical protocol, as well as to highlight the degree of variability to be expected in groundwater results. These subsections provide a general discussion of the data in Tables 4-5 through 4-22 on a parameter-by-parameter basis. Field blanks were collected by methods described in Subsection 3.3.5, and results for these are summarized in Tables 4-5 and 4-6.

4.6.1.1 Data Review - VOA Data

Results for the 32 priority pollutant VOA compounds plus MEK are summarized in tables separately from the inorganic analyses. Only those compounds actually detected have been listed. Due to the volatility of these compounds, VOA's are often difficult to sample, especially at low levels. They are easily driven off in the sampling process, or introduced as cross-contamination in sampling, storage, transport, or analysis. Several tests were run in the course of this investigation to validate VOA sampling methods. The sampling pump decontamination procedure was tested using a TCE spike (Subsection 3.3.5.3). Field blanks were collected in both rounds from both sampling pumps after decontamination. Traces of three VOA compounds were found in one field blank, and an anomalously high value of 1,1,1-trichloroethane was found in another (Table 4-5), indicating that the results for 1,1,1-trichloroethane (TCA) should be considered to have relatively low reliability. Verification samples (listed as W-1, W-2, and W-3) were collected from MW-210 by three different methods (bailer, pump with faulty valve, and pump with good valve) and analyzed by both GC and GC/MS to test the effect of a faulty valve on VOA results for the new monitor wells. A pumped sample (using a good valve) yielded VOA results approximately equivalent to a bailed sample; TCE concentrations between samples MW-210, W-1, and W-3 ranged from 0.109 to 0.260 mg/L, depending on both sampling and analytical methods. GC methods, specified by the task order, were used for all other VOA analyses. Second column confirmations were run on samples in which significant levels of VOA were found. These have been reported in the Laboratory QA/QC Report (Appendix L.5).

Table 4-5

Results of Analyses for U.S. EPA Volatile Organic Compounds and TOX, Monitor Well Field Blanks, 22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	FB-1 Jan	FB-2 Apr	FB-3 Jan	FB-4 Apr	FB-1 Jan	FB-2 Apr
Trans-1,2-Dichloroethene	0.0001	ND	ND	ND	ND	ND	0.00066
1,1,1-Trichloroethane	0.0001	0.017	ND	ND	ND	ND	ND
Trichloroethylene	0.0001	ND	ND	ND	ND	ND	0.00017
Tetrachloroethene	0.00005	ND	ND	ND	ND	ND	0.00032
Total Organic Halogens (TOX)	0.005	0.011	0.021	---	---	0.007	0.011

ND - Not detected above detection limits.
--- - Analysis not requested.

Table 4-6

Results of Analyses for TOC, Inorganics, and Pesticides
Monitor Well Field Blanks
22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	FB-1 Jan	FB-2 Jan	FB-1 Apr	FB-2 Apr
Specific conductance[1]	1.0	40	30	30	30
Total organic carbon	1.0	ND	ND	ND	ND
Oil and grease	0.1	4.5	2.7	ND	ND
Phenols	0.1	ND	ND	ND	ND
Nitrate	0.1	ND	ND	0.1	0.2
Cadmium	0.01	ND	ND	ND	ND
Chromium	0.05	ND	ND	ND	ND
Lead	0.02	ND	ND	ND	ND
Mercury	0.001	ND	ND	ND	ND
Silver	0.01	ND	ND	ND	ND
Endrin	0.00002	ND	ND	ND	ND
Lindane	0.00001	ND	ND	ND	ND
Methoxychlor	0.0002	ND	ND	ND	ND
Toxaphene	0.001	ND	ND	ND	ND
2,4-D	0.00006	ND	ND	ND	ND
2,4,5-TP	0.00006	ND	ND	ND	ND

[1]Reported in umhos/cm.

ND = Not detected above detection limit.

Some remarks can be made concerning specific VOA compounds based on the data in Appendix L. Methylene chloride was reported for many samples submitted in the first round, always at concentrations less than 0.001 mg/L. Methylene chloride at these concentrations is considered a laboratory artifact, and it has not been reported in the summary tables (L-1 through L-9). Ethylbenzene was found in several samples in the first round (at concentrations between 0.001 and 0.010 mg/L) and in none in the second round; ethylbenzene may therefore also be a sampling or laboratory artifact, although it has been reported in the summary tables. 1,1,1-trichloroethane (TCA) was found anomalously at levels up to 0.040 mg/L in several samples, especially in the second round, and at 0.017 mg/L in one of the field blanks; TCA (unlike TCE) showed very poor reproducibility between field duplicates and between rounds, and is not considered to have been confirmed at any of the points sampled in this investigation.

The following general rules will be applied in the evaluation of site-specific VOA data below: a compound will not be considered confirmed in a monitor well unless it was reported in both rounds of sampling. Reported concentrations of VOA compounds below 0.001 mg/L will be considered to have relatively lower reliability than reported concentrations above 0.001 mg/L. Background levels of all VOA compounds in groundwater should be considered zero, inasmuch as they are not naturally-occurring compounds.

4.6.1.2 <u>Data Review - New VOA Data</u>

TOX, TOC, and oil and grease analyses were conducted on all groundwater samples. All three analytical methods measure groups of organic compounds rather than individual components. Of these, TOX has the lowest detection limit (0.005 ug/L) and is therefore most likely to correlate with halogenated VOA compounds at the levels detected at CAFB. The detection limits for both TOC (1.0 mg/L) and oil and grease (0.1 mg/L) are in general too high for these parameters to be correlated to specific organic compounds such as TCE found in groundwater at CAFB. According to Harper (1984), the TOX method is considered "a very good approximation of the true total of all chlorine, bromine, or iodine from organic compounds. As such, it provides the potential to 'screen' a sample; to determine in one step whether significant quantities of halogenated organics are present. Since more than half of the EPA's priority pollutants are halogeneated, a straightforward screening measurement is thus available." Using the proportionate weight of chlorine in the TCE molecule, the TOX level should correspond to approximately 80

percent of the TCE concentration in a water sample in which TCE is the only chlorinated compound in solution. A review of the data in Tables 4-5 through 4-22 suggests that this correlation does not hold particularly well in the samples from CAFB, and that TOX is generally measured lower than would be expected. Furthermore, field blanks in which no VOA's were detected exhibited TOX levels up to 0.021 mg/L, suggesting that the experimental noise in the analysis is at least 0.021 mg/L. Therefore, TOX concentrations reviewed on site-by-site basis below will not be considered significant unless they exceed this value.

TOC was nondetected above 1.0 mg/L in most wells. TOC is a generalized screening parameter used to detect organic contaminants. Background levels of TOC in groundwater are usually below 1.0 mg/L, although it is not uncommon for TOC in shallow water table aquifers to range above 10 mg/L. For the purposes of data evaluation in this report, the background level of TOC will be considered to be less than 1.0 mg/L.

The oil and grease analysis was performed in the first round strictly according to the EPA recommended methodology, and a detection level better than 1.2 to 1.4 mg/L could not be obtained; experimental noise ranged up to 4.5 mg/L (based on field blank results in Table 4-6). Samples from the second round were concentrated first, then analyzed, and the required detection limit of 0.1 mg/L, with no detectable noise, was achieved in that round. Therefore, nondetectable at 0.1 mg/L should be considered background for oil and grease, and second-round results should be considered more reliable than the first round.

Phenols by EPA Method 420.1 were nondetected at 0.1 mg/L, except in a few samples where they were found at the detection limit. None of the five metals analyzed were detected in either round above their respective detection limits, listed in parentheses: cadmium (0.01 mg/L), chromium (0.05 mg/L), lead (0.02 mg/L), mercury (0.001 mg/L), silver (0.01 mg/L). None of the four pesticides analyzed were detected in either round: endrin (0.00002 mg/L), lindane (0.00001 mg/L), methoxychlor (0.0002 mg/L), toxaphene (0.001 mg/L). Of the two herbicides analyzed, 2,4-D (0.00006 mg/L) and 2,4,5-TP (0.00002 mg/L), only 2,4,5-TP was found at relatively low concentrations (<0.00010 mg/L) in a few groundwater samples.

Nitrate was analyzed by EPA Method 353.2, as specified in the Task Order, and reported as nitrate. This method actually measures nitrate and nitrite combined, because the sample is preserved with sulfuric acid. In general, nitrite is unstable and oxidizes to nitrate except under highly-reducing conditions, and nitrite in shallow groundwater (as in surface water) would be expected to represent a very small (5 percent) proportion of the total nitrate-nitrite concentrations measured. In the following discussions, reported concentrations for this parameter are treated as if they were for nitrate alone. Nitrate results exhibited very good reproducibility between duplicates and between rounds. Nitrate concentrations in shallow groundwater at CAFB exceeded 10 mg/L in all wells sampled, except MW-230 on the southern boundary corner, which is most likely affected by leakage from upgradient surface water sources, particularly Canal Creek. Normal background ranges were between 10 and 30 mg/L. This is consistent with Page (1977), who reported concentrations of nitrate (as nitrite) in groundwater between 6 and 29 mg/L (Table 2-5). For the purposes of site-specific data evaluation at CAFB, background values of nitrate will be considered to range up to 30 mg/L.

Specific conductance (in umhos/cm) and pH (in standard units) were both measured in the field within six hours of sample collection (usually within one hour). The specific conductance in groundwater at CAFB, when corrected to 25°C, ranged from 160 to 750 umhos/cm. A review of the specific conductance for wells located upgradient from potential sources of contamination suggests that the background range in the shallow aquifer is 160 to 450 umhos/cm. This corresponds well with the range of 162 to 438 umhos/cm reported for the shallow aquifer in Table 2-5. Values of pH measured in groundwater at CAFB ranged from 6.0 to 8.9 and were generally above 7.0. The reported background range for the shallow aquifer is 7.3 to 8.8 (Table 2-5).

4.6.1.3 Federal and State Water Quality Standards

A complete listing of applicable Federal and California drinking water and human health standards is provided in Appendix H. This subsection reviews the evolution and meaning of those standards.

The U.S. EPA originally promulgated a set of interim primary drinking water standards based on human health criteria in 1975, to which was added a set of recommended secondary drinking water standards based on taste, odor, and aesthetic considerations. In 1980, the U.S. EPA adopted the term "maximum contaminant level" (MCL) for all current drinking water standards.

On 28 November 1980, the U.S. EPA issued criteria for 64 toxic pollutant categories which could be found in water (Appendix M). The criteria established recommended maximum concentrations for acute and chronic exposure to these pollutants for both human and aquatic life. The derivation of these exposure values was based on cancer risk, toxic properties, and organoleptic properties.

The limits set for cancer risk were not based on a "safe" level for carcinogens in water. The criteria stated that, for maximum protection of human health, the concentration should be zero. However, where this cannot be achieved, a range of concentrations corresponding to incremental cancer risks of from 1 in 10 million to 1 in 100,000 was presented (10^{-7} to 10^{-5}).

In addition to the cancer risk assessment criteria, the EPA Office of Drinking Water provides, on request, advice on health effects concerning unregulated contaminants found in drinking water supplies. This information suggests the level of a contaminant in drinking water at which adverse health effects would not be anticipated with a margin of safety; it is called SNARL (suggested no adverse response level). Normally, values are provided for 1-day, 10-day, and longer-term exposure periods where available data exist. A SNARL does not condone the presence of a contaminant in drinking water, but rather provides useful information to assist in the setting of control

priorities in cases where the contaminant has been found. SNARL's are not legally enforceable standards, they are not issued as an official regulation, and they may or may not lead ultimately to the issuance of a national standard or maximum contamination level (MCL). The latter must take into account the occurrence and relative source contribution factors in addition to health effects. It is quite conceivable that the concentrations set for SNARL purposes might differ from an eventual MCL. The SNARL's may also change as additional information becomes available.

On 12 June 1984, the U.S. EPA published a set of proposed rules under the Safe Drinking Water Act that would establish recommended maximum contaminant levels (RMCL's) for the following volatile synthetic organic chemicals (VOA's) in drinking water: trichloroethylene, tetrachloroethylene, carbon tetrachloride, 1,1,1-trichloroethane, vinyl chloride, 1,2-dichloroethane, benzene, 1,1-dichloroethylene, and p-dichlorobenzene.

RMCL's are nonenforceable health goals that are to be set at levels that would result in no known or anticipated adverse health effects with an adequate margin of safety. This proposal is the initial stage of rulemaking for the establishment of primary drinking water regulations for the 9 VOA's. Following this proposal, maximum contaminant levels (MCL's) and monitoring/reporting requirements will be proposed when the MCL's are promulgated. MCL's will be enforceable standards. They are to be set as close to the RMCL's as is feasible, and are based on health, treatment technologies, costs, and other factors. It is anticipated that RMCL's for most of the compounds listed would be set in the range of 0.005 to 0.05 mg/L. EPA anticipates proposing additional RMCL's for other VOA compounds in the near future.

The State of California has adopted current Federal MCL's for 20 chemicals and radionuclides. In addition, the California Department of Health Services (CDHS) has established drinking water action levels currently covering 43 chemicals (Appendix M). These action levels, like SNARL's, are based exclusively on health risks, but, unlike SNARL's, are not merely advisory. Instead, they are enforced as MCL's for drinking water supplies in the State of California. In March 1985, they were adopted as guidance criteria for cleanup at hazardous substance sites by the California Water Resources Control Board (CWRCB).

Table 4-7 lists the applicable Federal and State water quality standards for the analytes sampled at CAFB. The last column in Table 4-7 lists the wells at CAFB in which the referenced standard was exceeded at least once. The CDHS action level for TCE was found to be exceeded at wells in the Main Base, East, and West Flightline Sectors. The action level for benzene was exceeded at two wells in the Main Base Sector. The Federal standard for pH was not met at three wells in the South, East, and West Flightline Sectors. The Federal standard for nitrate (as nitrate) was exceeded in monitor wells in the Main Base and was associated with SLFZ, NLFZ, and WLFZ. None of the other applicable standards (for 10 VOA's, five metals, four pesticides, and two herbicides) were exceeded in groundwater sampled at CAFB.

4.6.2 Site-Specific Groundwater Results

In this subsection, groundwater results are evaluated on a sector-by-sector and site-specific basis, following the criteria set out in the previous subsection, including background levels and water quality standards.

4.6.2.1 Main Base Sector

Six investigation sites are located in the Main Base Sector (Table 1-2). These were monitored by means of six existing test wells (TW-13 through TW-18) and five new monitor wells (MW-210, MW-220, MW-290, MW-300, and MW-310). In addition, production wells in the Main Base Sector and off-Base family housing area were monitored, including six wells open to the confined aquifer, and the new production well open to both the confined and deep aquifers. Groundwater data for the Main Base Sector have been summarized in Tables 4-8 through 4-13.

Of the VOA compounds sampled in the shallow aquifer (Tables 4-10 and 4-12), the only one consistently detected at significant concentrations and confirmed in both rounds was TCE, ranging in concentration from <0.001 mg/L at MW-290 to 0.280 mg/L at TW-14. Apart from TCE, the following compounds were also detected in shallow aquifer monitor wells.

Table 4-7

Comparison of Groundwater Results with Applicable Water Quality Standards

Analyte	Water Quality Standards	Reference	Well at or Exceeding Standard at Least Once
VOA's (mg/L)			
Methylene chloride	0.040	(1)	None
1,1-dichloroethene	LOQ (0.0001-0.0004)	(1)	None
1,1-dichloroethane	0.0010	(1)	None
1,1,1-trichloroethane	0.200	(1)	None
Carbon tetrachloroide	0.0050	(1)	None
1,2-dichloropropane	0.010	(1)	None
Trichloroethylene	0.0050	(1)	PW-1*, PW-2*, PW-3, PW-4*, PW-5*, TW-13, TW-14, TW-16*, TW-17, TW-18, MW-210, MW-220*, MW-300, MW-310, MW-330, MW-440, and MW-470*
1,2-dichlorobenzene 1,3-dichlorobenzene 1,4-dichlorobenzene	0.130 (for a single isomer or sum of three)	(1)	None
Benzene	0.00070	(1)	TW-14, TW-16*
Toluene	0.100	(1)	None
pH (S.U.)	6.5 8.5	(2)	MW-240, MW-390, MW-470
Specific conductance (umhos/cm)	None	---	---
Total organic halogens (mg/L)	None	---	---

Table 4-7
(continued)

Analyte	Water Quality Standards	Reference	Well at or Exceeding Standard at Least Once
Total organic carbon (mg/L)	None	---	---
Oil and grease (mg/L)	None	---	---
Phenols (mg/L)	None	---	---
Nitrate, as N (mg/L) as nitrate (mg/L)	10.0 45	(2)	TW-12, TW-13, TW-15, TW-17, MW-250, MW-270*, MW-360, MW-370*, MW-380, MW-390*, MW-400*, MW-410*,
Cadmium (mg/L)	0.010	(2)	None
Chromium (mg/L)	0.050	(2)	None
Lead (mg/L)	0.050	(2)	None
Mercury (mg/L)	0.002	(2)	None
Silver (mg/L)	0.050	(2)	None
Endrin (mg/L)	0.0002	(2)	None
Lindane (mg/L)	0.004	(2)	None
Methoxychlor (mg/L)	0.1	(2)	None
Toxaphene (mg/)	0.005	(2)	None
2,4-D (mg/)	0.1	(2)	None
2,4,5-TP (mg/L)	0.010	(2)	None

References for water quality standard:

(1) California DHS Action Level.
(2) Federal MCL (Primary or Secondary Drinking Water Standard)

*Analyte detected in only one round -- not confirmed.

Table 4-8

Results of Analyses for U.S. EPA Volatile Organic Compounds and TOX, Base Production Wells, Main Base Sector, 22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	New PW Jan	New PW Apr	PW-1 Jan	PW-1 Jan Dup	PW-1 Apr	PW-2 Jan	PW-2 Apr	PW-3 Jan	PW-3 Apr	PW-4 Apr	PW-7 Jan	PW-7 Jan Dup	PW-7 Apr	PW-8 Jan	PW-8 Apr	PW-8 Apr Dup
Trans-1,2-Dichloroethene	0.0001	ND	ND	ND	ND	ND	ND	ND	0.0014	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	0.00002	ND	ND	ND	ND	ND	0.00076	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	0.0001	ND	0.026	ND	ND	ND	ND	ND	ND	0.00026	0.00046	ND	ND	ND	ND	ND	0.040
Trichloroethylene	0.0001	ND	ND	ND	ND	0.012	ND	0.020	0.025	0.044	0.032	ND	ND	ND	ND	ND	ND
Tetrachloroethylene	0.00005	ND	ND	ND	0.00012	ND	ND	ND	ND	ND	ND	0.00024	0.00013	ND	ND	ND	ND
Chlorobenzene	0.0003	ND	ND	ND	ND	ND	ND	0.0010	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	0.0002	ND	ND	ND	0.00033	ND	0.00032	ND	0.00032	ND	ND	0.00030	0.00031	ND	ND	ND	ND
Benzene	0.0002	ND	ND	ND	ND	0.00021	ND	ND	ND	ND	0.00022	ND	ND	ND	ND	ND	ND
Ethylbenzene	0.0002	ND	ND	ND	0.0067	ND	ND	ND	ND	ND	ND	0.0015	ND	ND	ND	ND	ND
Total organic halogens (TOX)	0.005	ND	0.019	ND	ND	0.007	0.017	0.014	0.022	0.007	0.019	ND	0.006	ND	0.005	0.057	0.031

ND - Not detected above detection limit.

Table 4-9

Results of Analyses for TOC, Inorganics, and Pesticides, Base Production Wells, Main Base Sector, 22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	New PW Jan	New PW Apr	PW-1 Jan	PW-1 Jan Dup	PW-1 Apr	PW-2 Jan	PW-2 Apr	PW-3 Jan	PW-3 Apr	PW-4 Apr	PW-7 Jan	PW-7 Jan Dup	PW-7 Apr	PW-8 Jan	PW-8 Apr	PW-8 Apr Dup
pH[1]	0.1	7.3	7.1	7.8		7.2	7.9	7.5	7.6	7.4	7.5	7.5		7.5	7.7	7.5	
Specific conductance[2]	1.0	360	280	260		280	250	280	340	270	270	290		290	270	270	
Total organic carbon	1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0
Oil and grease	0.1	0.9	0.9	<0.5	<0.5	ND	1.0	ND	1.0	0.7	ND	1.0	<0.5	(3)	1.0	0.8	(3)
Phenols	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate	0.1	---	---	---	---	---	---	---	---	---	23	---	---	---	---	---	---
Cadmium	0.1	---	---	---	---	---	---	---	---	---	ND	---	---	---	---	---	---
Chromium	0.001	---	---	---	---	---	---	---	---	---	ND	---	---	---	---	---	---
Lead	0.05	---	---	---	---	---	---	---	---	---	ND	---	---	---	---	---	---
Mercury	0.02	---	---	---	---	---	---	---	---	---	ND	---	---	---	---	---	---
Silver	0.001	---	---	---	---	---	---	---	---	---	ND	---	---	---	---	---	---
Endrin	0.00002	---	---	---	---	---	---	---	---	---	ND	---	---	---	---	---	---
Lindane	0.00001	---	---	---	---	---	---	---	---	---	ND	---	---	---	---	---	---
Methoxychlor	0.0002	---	---	---	---	---	---	---	---	---	ND	---	---	---	---	---	---
Toxaphene	0.001	---	---	---	---	---	---	---	---	---	ND	---	---	---	---	---	---
2,4-D	0.00006	---	---	---	---	---	---	---	---	---	ND	---	---	---	---	---	---
2,4,5-TP	0.00006	---	---	---	---	---	---	---	---	---	ND	---	---	---	---	---	---

ND - Not detected above detection limit.
--- - Analysis not requested.

[1]Reported in standard units. Duplicate measurements averaged and reported as a single value.
[2]Reported in umhos/cm. Duplicate measurements averaged and reported as a single value.
[3]Sample container broken in transport or analysis.

Table 4-10

Results of Analyses for U.S. EPA Volatile Organic Compounds and TOX, Monitor Wells, Main Base Sector, 22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	MW-210 Jan	MW-210 Jan Dup	MW-210 Apr	MW-210 Apr Dup	MW-210 Jan	MW-220 Apr	MW-220 Apr Dup	MW-290 Jan	MW-290 Apr	MW-300 Jan	MW-300 Apr	MW-300 Apr Dup	MW-310 Jan	MW-310 Jan Dup	MW-310 Apr
1,1-Dichloroethane	0.0001	ND	ND	ND	ND	0.00032	ND	ND	ND	ND	ND	0.0022	ND	ND	ND	ND
Trans-1,2-Dichloroethene	0.0001	ND	ND	0.00060	0.00030	0.00074	ND	ND	ND	ND	ND	ND	ND	0.0019	0.0011	0.0020
1,1,1-Trichloroethane	0.0001	0.0049	0.0051	ND	ND	ND	ND	ND	ND	ND	0.0014	ND	0.021	0.0027	0.0040	ND
Carbon tetrachloride	0.0001	ND	ND	ND	ND	0.00051	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	0.0001	0.067	0.086	0.230	0.260	0.036	ND	ND	ND	0.00098	0.0042	0.059	0.043	0.022	0.013	0.070
Tetrachloroethylene	0.00005	0.0068	0.0085	0.037	0.041	ND	ND	ND	ND	ND	ND	0.00034	ND	0.00005	ND	ND
Benzene	0.0002	ND	ND	0.00038	ND	ND	ND	ND	0.00042	0.00023	0.00025	ND	ND	ND	ND	ND
Total organic halogens (TOX)	0.005	0.051	0.040	0.045	---	0.037	0.026	0.029	0.015	0.005	0.026	0.011	0.013	0.020	0.018	0.010

ND - Not detected above detection limit.
--- - Analysis not requested.

Table 4-11

Results of Analyses for TOC, Inorganics, and Pesticides, Test Wells, Main Base Sector, 14 November, 22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	TW-13 Jan	TW-13 Apr	TW-14 Jan	TW-14 Apr	TW-15 Jan	TW-15 Apr	TW-16 Jan	TW-16 Apr	TW-16 Apr Dup	TW-17 Jan	TW-17 Apr	TW-18 Jan	TW-18 Apr
pH[1]	0.1	7.1	6.9	7.2	7.0	7.1	7.0	7.3	6.7	6.7	7.0	7.0	7.3	7.3
Specific conductance[2]	1.0	630	590	540	500	640	580	460	460		510	550	400	370
Total organic carbon	1.0	ND	1.3	ND	ND	ND	ND	ND	ND	ND	ND	1.5	ND	ND
Oil and grease	0.1	<1.3	ND	<1.4	ND	<1.5	ND	<1.4	(3)	ND	14	14	<1.3	ND
Phenols	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate	0.1	61	57	---	---	64	62	---	---	---	47	46	---	---
Cadmium	0.01	ND	ND	---	---	ND	ND	---	---	---	ND	ND	---	---
Chromium	0.05	ND	ND	---	---	ND	ND	---	---	---	ND	ND	---	---
Lead	0.02	ND	ND	---	---	ND	ND	---	---	---	ND	ND	---	---
Mercury	0.001	ND	ND	---	---	ND	ND	---	---	---	ND	ND	---	---
Silver	0.01	ND	ND	---	---	ND	ND	---	---	---	ND	ND	---	---
Endrin	0.00002	ND	ND	---	---	ND	ND	---	---	---	ND	ND	---	---
Lindane	0.00001	ND	ND	---	---	ND	ND	---	---	---	ND	ND	---	---
Methoxychlor	0.0002	ND	ND	---	---	ND	ND	---	---	---	ND	ND	---	---
Toxaphene	0.001	ND	ND	---	---	ND	ND	---	---	---	ND	ND	---	---
2,4-D	0.00006	ND	ND	---	---	ND	ND	---	---	---	ND	ND	---	---
2,4,5-TP	0.00006	ND	ND	---	---	ND	ND	---	---	---	ND	ND	---	---

ND - Not detected above detection limit.
--- - Analysis not requested.

[1]Reported in standard units. Duplicate measurements averaged and reported as a single value.
[2]Reported in umhos/cm. Duplicate measurements averaged and reported as a single value.
[3]Sample container broken in transport or analysis.

Table 4-12

Results of Analyses for U.S. EPA Volatile Organic Compounds and TOX, Test Wells, Main Base Sector, 14 November 1984, 22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	TW-13 Jan	TW-13 Apr	TW-14 Nov	TW-14 Jan	TW-14 Apr	TW-15 Jan	TW-15 Apr	TW-16 Jan	TW-16 Apr	TW-16 Apr Dup	TW-17 Jan	TW-17 Apr	TW-18 Jan	TW-18 Apr
Vinyl chloride	0.0002	ND	0.00022	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.00022	ND	ND
Chloroethane	0.0005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0034	ND	ND
1,2-Dichloroethane	0.0001	ND	ND	ND	ND	0.0017	ND	ND	ND	0.032	0.020	ND	ND	ND	0.0040
Trans-1,2-Chloroethene	0.0001	ND	0.0010	0.0072	ND	0.0028	ND	0.00038	ND	ND	0.0042	ND	0.00098	0.0016	0.0013
Chloroform	0.0001	ND	ND	0.0031	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	0.0001	ND	ND	0.00016	ND	ND	ND	0.018	ND	0.00042	0.021	ND	0.020	ND	ND
Carbon tetrachloride	0.0001	ND	ND	0.00027	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	0.0001	0.067	0.100	0.260	0.220	0.280	0.021	0.039	ND	0.160	0.130	0.040	0.110	0.120	0.150
Tetrachloroethene	0.00005	ND	ND	0.00029	0.00025	0.00073	ND	ND	ND	ND	ND	ND	ND	0.00037	ND
Chlorobenzene	0.0003	ND	ND	ND	ND	ND	0.00075	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	0.0002	ND	ND	ND	ND	ND	ND	ND	0.00084	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	0.0003	ND	ND	ND	ND	ND	ND	ND	0.0016	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	0.0002	ND	ND	ND	0.00089	ND	ND	ND	0.0013	ND	ND	ND	ND	ND	ND
Benzene	0.0002	ND	ND	ND	0.00082	0.00079	ND	ND	0.00075	ND	ND	ND	ND	ND	ND
Ethylbenzene	0.0002	0.0011	ND	ND	0.0028	ND	ND	ND	ND	ND	ND	0.0027	ND	ND	ND
Total organic halogens (TOX)	0.005	0.034	0.025	---	0.045	0.046	0.018	0.016	0.031	0.022	0.026	0.026	0.026	0.044	0.044

ND - Not detected above detection limit.
--- - Analysis not requested.

Table 4-13

Results of Analyses for TOC, Inorganics, and Pesticides, Monitor Wells, Main Base Sector, 22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	MW-210 Jan	MW-210 Jan Dup	MW-210 Apr	MW-220 Jan	MW-220 Apr	MW-220 Apr Dup	MW-290 Jan	MW-290 Apr	MW-300 Jan	MW-300 Apr	MW-300 Apr Dup	MW-310 Jan	MW-310 Jan Dup	MW-310 Apr
pH[1]	0.1	7.5	7.5	6.9	7.2	6.9	6.8	8.0	7.6	7.7	7.8	7.8	7.6	7.6	7.4
Specific conductance[2]	1.0	480		(3)	510	460		390	340	480	420		490		420
Total organic carbon	1.0	6.0	ND	ND	ND	ND	ND	ND	1.2	ND	ND	ND	ND	ND	1.1
Oil and grease	0.1	<1.0	<1.0	0.5	<1.1	ND	ND	<1.1	ND	1.2	0.4	1.0	1.2	2.5	0.6
Phenols	0.1	ND	ND	ND	ND	ND	ND	---	---	---	---	---	---	---	---
Nitrate	0.1	---	---	---	---	---	---	---	---	---	---	---	---	---	---

ND - Not detected above detection limit.
--- - Analysis not requested.

[1]Reported in standard units. Duplicate measurements averaged and reported as a single value.
[2]Reported in umhos/cm. Duplicate measurements averaged and reported as a single value.
[3]Sample container broken in transport or analysis.

• trans-1,2-dichloroethene	confirmed at MW-310	(0.011 to 0.0020 mg/L)
• tetrachloroethylene	confirmed at MW-210	(0.0068 to 0.041 mg/L)
	confirmed at TW-14	(0.00029 to 0.00073 mg/L)
• benzene	confirmed at MW-290	(0.00023 to 0.00042 mg/L)
	confirmed at TW-14	(0.00079 to 0.00082 mg/L)

For the production wells, TCE was confirmed in PW-3 (0.025 to 0.044 mg/L); and was detected intermittently in PW-1, PW-2, and PW-4; no volatiles (except for an anomalous value of TCA) were found in the family housing wells (PW-7 and PW-8).

TCE concentrations measured in the April 1985 samples were generally higher than in January. The April concentrations were used to draw the plume map shown in Figure 4-18. (The nondetected result at MW-220 is considered anomalous.) Based on this map, the source of TCE contamination is clearly in the Main Base Sector rather than in the South Sector, and TCE-contaminated groundwater is moving off-Base in the shallow aquifer following the direction of groundwater flow as depicted in Figure 4-18.

Test wells (TW-14, TW-16, and TW-18) and monitor wells (MW-210 and MW-220) within the plume generally exhibited elevated levels of TOX (greater than 0.21 mg/L), but TOC, oil and grease, and phenols were generally not detected in association with elevated concentrations of TCE. Production wells open in the confined aquifer beneath the shallow aquifer plume (PW-1 through PW-4) exhibited elevated levels of TCE, as well as TOX, and nondetectable levels of TOC and phenols; occasional detectable levels of oil and grease (up to 1.0 mg/L) are thought to be related to the use of oil-lubricated pumps in these wells. Specific conductance and pH were within the background ranges in all the Main Base Sector and family housing production wells.

The location of the source of the TCE plume cannot be determined exactly from the plume map (Figure 4-18). Either it is at or near the center (most concentrated part) of the plume, if TCE is still being generated at the source (Building T-52 would represent such a source) or the plume has moved downgradient from a historic source that is no longer actively contributing

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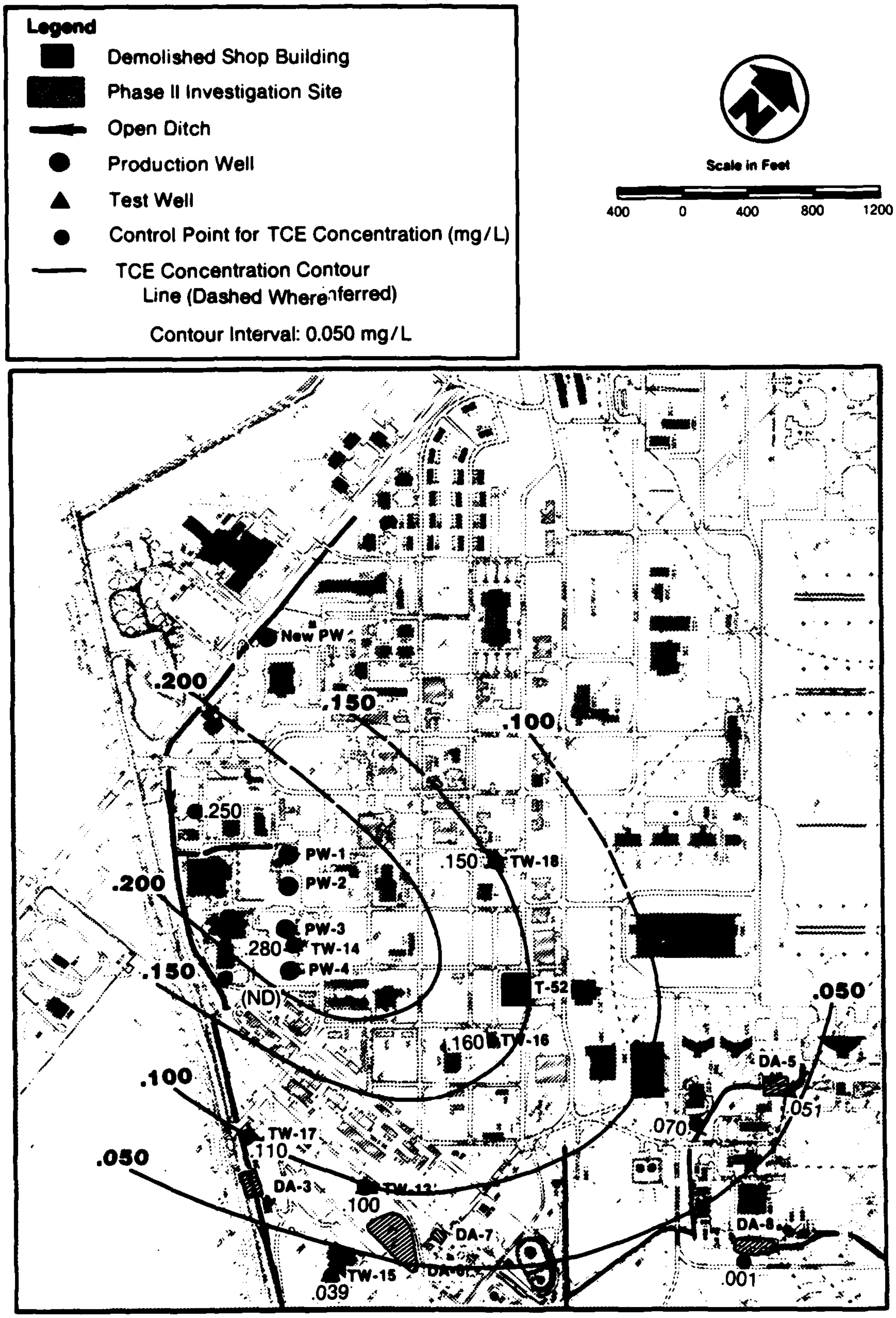

FIGURE 4-18 TCE CONCENTRATION IN THE SHALLOW AQUIFER, MAIN BASE SECTOR, APRIL 1985

TCE to groundwater. The area in the vicinity of DA-8 would be the logical historical source in this case. A further complication is that perched groundwater contaminated with TCE at relatively high concentrations may be present above the shallow clay beneath the DA-8 area. This contaminated perched water would not enter the main body of the shallow aquifer except where the shallow clay pinches out, somewhat downgradient and west of DA-8.

A comparison of water quality results between MW-240, the upgradient moniter well for DA-8, and MW-300 and MW-310, the two downgradient monitor wells, indicates that there is clearly some contribution of TCE to shallow groundwater from DA-8 or other nearby portions of the fighter squadron maintenance area. In addition, there is a slight increase in specific conductance (from an average of 370 to an average of 450 umhos/cm) and oil and grease (from nondetected to an average of 1.0 mg/L) from the upgradient to the downgradient side of DA-8. Further investigation would be required to determine the presence of perched water and the chemical constitutents in that water.

DA-6, the old industrial sewage lagoon area, was the only other site in the Main Base Sector where shallow groundwater was monitored, using TW-13, TW-15, and TW-17 in the shallow aquifer and PW-4 in the confined aquifer. In fact, TW-13 is located immediately downgradient and within 200 feet of the historic location of DA-6. TW-17 is closer to DA-3, the CE yard washrack. All three test wells were found to have almost neutral pH (6.9 to 7.1), relatively elevated levels of specific conductance (510 to 640 umhos/cm) and nitrate (46 to 64 mg/L), and undetected TOC, phenols, metals, and pesticides. Oil and grease was undetected in either TW-13 or TW-15. However, TW-17 was found to contain a clear, oily substance floating on the water; this well also exhibited the highest level of oil and grease of any of the wells sampled at CAFB (14 mg/L in both rounds). Contamination of the well with an oily substance has been known by the Base for approximately one year, and a sample of oil on water was gathered by the Base BEE office using a bailer in August 1984 when the pump had been removed for servicing. The concentration of oil and grease in the water fraction of this sample, reported by OEHL, was 516.0 mg/L.

TCE was the only VOA compound confirmed in the three test wells, with TW-13 and TW-17 having approximately equal concentrations (0.040 to 0.110 mg/L) and TW-15 having slightly lower concentrations (0.021 to 0.039 mg/L). PW-4 (sampled in April only) had a somewhat lower specific conductance (270 umhos/cm) and nitrate concentration (23 mg/L) than the test wells, but had a TCE level of 0.032 mg/L, consistent with surrounding production wells located beneath the center of the TCE plume in the shallow aquifer. On the basis of this analysis, DA-6 would not be considered an active source of either volatile organic or inorganic contamination. However, DA-3, which has associated dry well disposal, as well as direct discharge to the ditch, is the most likely source for the oily contamination found in TW-17. Further investigations would be required to identify the oily substance and determine the magnitude and extent of this product in the shallow aquifer.

4.6.2.2 South Sector

Two landfills (LF-1 and LF-2), DA-1 at the jet engine test cell, and four disposal pits were monitored together in the South Landfill Zone (SLFZ) by two upgradient wells (MW-230 and MW-240) and five downgradient wells (TW-12, MW-250, MW-260, MW-270, MW-280) in the shallow aquifer. Water quality data from sampling of these six monitor wells have been summarized in Tables 4-14 and 4-15.

Of the VOA compounds, only a few were found, in both upgradient and downgradient wells, at concentrations generally less than 0.001 mg/L. The only confirmed VOA compound was tetrachloroethylene in TW-12 (0.0002 to 0.0012 mg/L).

Metals, pesticides, and herbicides were nondetected (except for a trace of 2,4,5-TP in MW-260 in one round), and phenols were found at or below the detection limit.

TOC ranged between nondetected and 2 mg/L, and oil and grease between nondetected and 13 mg/L; neither analyte exhibited good consistency between rounds or a significant contrast from upgradient to downgradient wells. Specific conductance did exhibit

Table 4-14

Results of Analyses for U.S. EPA Volatile Organic Compounds and TOX, Monitor Wells and Test Wells, South Sector, 22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	TW-12 Jan	TW-12 Jan Dup	TW-12 Apr	MW-230 Jan	MW-230 Apr	MW-240 Jan	MW-240 Apr	MW-240 Apr Dup	MW-250 Jan	MW-250 Apr	MW-260 Jan	MW-260 Jan Dup	MW-260 Apr	MW-270 Jan	MW-270 Apr	MW-280 Jan	MW-280 Apr
1,1,1-Trichloroethane	0.0001	ND	ND	0.0012	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	0.0001	ND	ND	ND	ND	0.0034	ND	ND	ND	ND	ND	0.00015	ND	0.00023	ND	ND	ND	ND
Tetrachloroethene	0.00005	0.00033	0.00020	0.0012	ND	ND	ND	ND	ND	ND	ND	0.00006	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	0.0003	0.0018	0.00051	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	0.0002	0.0010	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	0.0002	ND	ND	ND	0.00045	ND	0.00032	ND	ND	0.00034	ND	0.00038	ND	ND	ND	ND	ND	ND
Toluene	0.0002	ND	ND	ND	0.00021	ND	ND	ND	ND	ND	ND	0.00029	ND	ND	ND	ND	ND	ND
Methyl ethyl ketone	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.002	ND	ND	ND	ND	ND	ND
Total organic halogens (TOX)	0.005	0.031	0.0013	0.011	0.018	0.013	0.006	0.007	0.008	0.021	0.039	0.031	0.023	0.013	0.011	0.018	0.013	0.005

ND - Not detected above detection limit.

Table 4-15

Results of Analyses for TOC, Inorganics, and Pesticides, Monitor Wells and Test Well, South Sector, 22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	TW-12 Jan	TW-12 Jan Dup	TW-12 Apr	MW-230 Jan	MW-230 Apr	MW-240 Jan	MW-240 Apr	MW-240 Apr Dup	MW-250 Jan	MW-250 Apr	MW-260 Jan	MW-260 Jan Dup	MW-260 Apr	MW-270 Jan	MW-270 Apr	MW-280 Jan	MW-280 Apr
pH[1]	0.1	7.4		6.9	7.3	7.0	7.1	6.3	6.3	7.5	7.1	7.2	7.2	7.2	7.5	6.8	8.1	6.9
Specific conductance[2]	1.0	680		600	300	280	340	300		570	640	750		750	670	690	420	410
Total organic carbon	0.1	1	ND	ND	2	2	ND	ND	2	ND	2	1	2	2	1	1.2	ND	ND
Oil and Grease	1.0	<1.2	<1.4	ND	1.2	2.5	<1.0	1.0	0.8	3.2	0.6	<1.1	4.0	0.6	13	ND	5.6	0.8
Phenols	0.1	ND	ND	ND	0.1	ND	ND	ND	ND	0.1	ND	ND	ND	ND	0.1	ND	ND	ND
Nitrate	0.1	64	66	65	1.4	7.7	18	13	13	74	72	41	41	33	43	45	15	15
Cadmium	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	0.00002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lindane	0.00001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toxaphene	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-D	0.00006	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4,5-TP	0.00006	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.00006	ND	ND	ND	ND	ND	ND

ND - Not detected above detection limits.
--- - Analysis not requested.

[1]Reported in standard units. Duplicate measurements averaged and reported as a single value.
[2]Reported in umhos/cm. Duplicate measurements averaged and reported as a single value.
[3]Sample container broken in transport or analysis.

such a contrast, ranging between 280 and 340 umhos/cm in upgradient wells to as much as 750 umhos/cm in MW-260. This trend was closely paralleled by nitrate concentrations, which were between 1.4 and 18 mg/L in upgradient wells and up to 74 mg/L in MW-250. Figure 4-19 illustrates a plume of mineralized groundwater emanating from the area of LF-1 and moving northward into the Main Base Sector following the direction of groundwater flow illustrated in Figure 4-8. Plume contours are based on specific conductance measurements made in April 1985. This map confirms that existing monitor wells are downgradient from and impacted by the SLFZ. If the SLFZ were an active source of VOA contamination, significant concentrations of VOA's would be expected in downgradient wells, particularly in TW-12, MW-250, MW-260, and MW-270.

Based on this evaluation, the SLFZ does not appear to be a significant active source of TCE or other VOA compounds in groundwater. The SLFZ (LF-1 in particular) appears to be affecting the inorganic load in downgradient groundwater, but none of the analytes monitored were found to exceed Federal or State standards except for nitrate.

4.6.2.3 East Sector

Five new monitor wells were installed in the East Sector to monitor two sites, FT-1 and LF-3. MW-320 is located upgradient from FT-1 (as confirmed in historic aerial photographs); MW-330 and MW-340 are located downgradient. In addition, four existing wells were also sampled: PW-11 located upgradient of FT-1 and downgradient of LF-3; and PW-5, PW-6, and TW-19 located cross-gradient from both sites (Figure 4-9). MW-460 and MW-470 were planned to be downgradient from LF-3, but of the two only MW-470 is truly downgradient. MW-460 can be considered cross-gradient. Water quality data obtained have been summarized in Tables 4-16 through 4-19.

Of the VOA compounds analyzed, only TCE was confirmed (as defined in Subsection 4.6.1.1) in a single monitor well (MW-330) at 0.0042 to 0.0063 mg/L (Table 4-18). 1,1,1-trichloroethane, toluene, and an anomalously high value of TCE in MW-470 (0.045 mg/L) are considered unconfirmed. None of the VOA's detected in TW-19, PW-5, PW-6, or PW-11 can be considered confirmed, although TCE was detected in PW-5 and PW-6 in the first round. The following compounds were detected at least once in one well: 1,2-trichloroethane, 1,1,1-trichloroethane, 1,4-dichlorobenzene, benzene, and ethylbenzene. None of the wells monitored exhibited TOX levels consistently in excess of 0.021 mg/L.

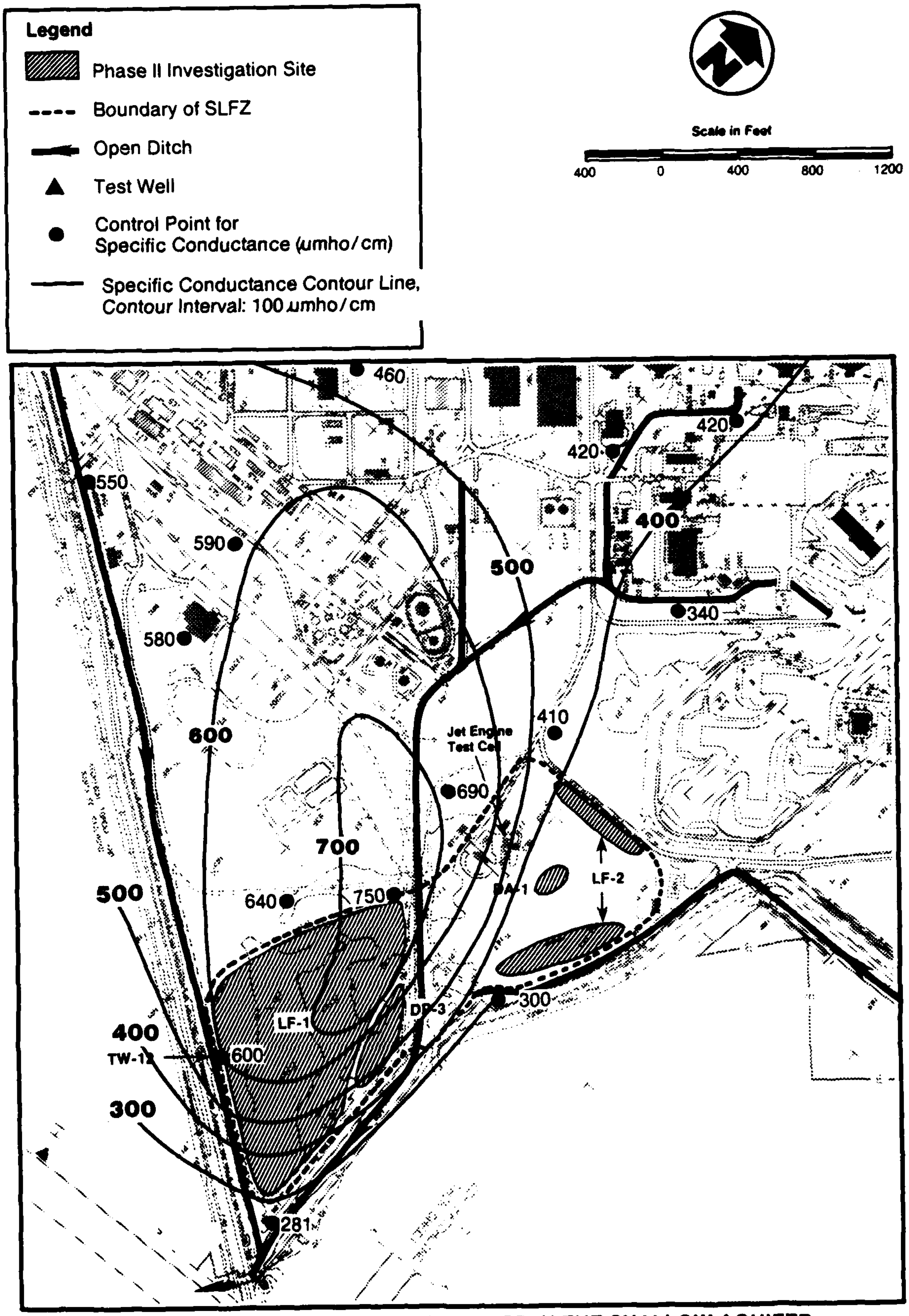

FIGURE 4-19 SPECIFIC CONDUCTANCE IN THE SHALLOW AQUIFER, SOUTH SECTOR, APRIL 1985

Table 4-16

Results of Analyses for U.S. EPA Volatile Organic Compounds and TOX,
Test Wells and Base Production Wells, East Sector,
22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	TW-19 Jan	TW-19 Apr	PW-5 Jan	PW-5 Apr	PW-5 Apr Dup	PW-6 Jan	PW-6 Apr	PW-11 Jan	TW-19 Apr
1,2-Dichloroethane	0.00002	ND	ND	0.00086	ND	ND	0.00075	ND	ND	ND
1,1,1-Trichloroethane	0.0001	ND	ND	ND	0.0012	0.040	ND	0.0026	ND	0.026
Trichloroethylene	0.0001	ND	ND	0.0073	ND	ND	0.0013	ND	ND	ND
1,4-Dichlorobenzene	0.0002	ND	ND	0.00030	ND	ND	ND	ND	0.00031	ND
Benzene	0.0002	ND	0.00031	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	0.0002	ND	ND	0.0030	ND	ND	ND	ND	ND	ND
Total organic halogens (TOX)	0.005	ND	0.014	0.012	0.009	ND	0.010	ND	0.021	ND

ND - Not detected above detection limits

Table 4-17

Results of Analyses for TOC, Inorganics, and Pesticides, Test Well and Base Production Wells, East Sector, 22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	TW-19 Jan	TW-19 Apr	PW-5 Jan	PW-5 Apr	PW-5 Apr Dup	PW-6 Jan	PW-6 Apr	PW-11 Jan	PW-11 Apr
pH[1]	0.1	7.6	7.4	7.7	7.5	7.5	7.5	7.6	7.4	7.5
Specific conductance[2]	1.0	320	270	230	230		230	230	220	220
Total organic carbon	1.0	ND	ND	ND	1.0	1.0	ND	1.8	ND	ND
Oil and grease	0.1	<1.7	0.5	<0.5	1.0	1.5	<0.5	ND	<0.5	ND
Phenols	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate	0.1	27	26	17	18	18	17	18	17	17

ND - Not detected above detection limits.

[1]Reported in standard units.
[2]Reported in umhos/cm.

Table 4-18

Results of Analyses for U.S. EPA Volatile Organic Compounds and TOX,
Monitor Wells, East Sector,
22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	MW-320 Jan	MW-320 Apr	MW-330 Jan	MW-330 Apr	MW-330 Apr Dup	MW-340 Jan	MW-340 Apr	MW-460 Jan	MW-460 Jan Dup	MW-460 Apr	MW-470 Jan	MW-470 Apr
1,1,1-Trichloroethane	0.0001	0.0055	ND	0.0072	ND	ND	ND	ND	0.0080	ND	ND	ND	ND
Trichloroethylene	0.0001	ND	0.0042	0.00044	0.0063	0.0056	ND	ND	ND	ND	ND	ND	0.045
Toluene	0.0002	ND	ND	ND	ND	ND	ND	ND	0.00046	ND	ND	ND	ND
Total Organic Halogens (TOX)	0.005	0.011	ND	0.023	0.013	ND	0.007	0.018	ND	0.013	ND	0.031	0.013

ND - Not detected above detection limits.

Table 4-19

Results of Analyses for TOC, Inorganics, and Pesticides, Monitor Wells, East Sector, 22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	MW-320 Jan	MW-320 Apr	MW-330 Jan	MW-330 Apr	MW-330 Apr Dup	MW-340 Jan	MW-340 Apr	MW-460 Jan	MW-460 Jan Dup	MW-460 Apr	MW-470 Jan	MW-470 Apr
pH[1]	0.1	7.8	8.2	8.4	7.7	7.7	8.0	7.6	8.1	8.0	7.9	8.5	7.9
Specific conductance[2]	1.0	320	230	290	270		280	230	250		210	280	230
Total organic carbon	1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	3	ND	ND
Oil and grease	0.1	<1.4	ND	2.4	ND	0.6	<1.3	ND	5.3	(3)	0.8	5.1	ND
Phenols	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate	0.1	18	18	22	21	21	20	20	12	12	12	12	12
Cadmium	0.01	---	---	---	---	---	---	---	ND	ND	ND	ND	ND
Chromium	0.05	---	---	---	---	---	---	---	ND	ND	ND	ND	ND
Lead	0.02	---	---	---	---	---	---	---	ND	ND	ND	ND	ND
Mercury	0.001	---	---	---	---	---	---	---	ND	ND	ND	ND	ND
Silver	0.01	---	---	---	---	---	---	---	ND	ND	ND	ND	ND
Endrin	0.00002	---	---	---	---	---	---	---	ND	ND	ND	ND	ND
Lindane	0.00001	---	---	---	---	---	---	---	ND	ND	ND	ND	ND
Methoxychlor	0.0002	---	---	---	---	---	---	---	ND	ND	ND	ND	ND
Toxaphene	0.001	---	---	---	---	---	---	---	ND	ND	ND	ND	ND
2,4-D	0.00006	---	---	---	---	---	---	---	ND	ND	ND	ND	ND
2,4,5-TP	0.00006	---	---	---	---	---	---	---	ND	ND	ND	ND	0.00008	ND

ND - Not detected above detection limit.
--- - Analysis not requested.

[1]Reported in standard units. Duplicate measurements averaged and reported as a single value.
[2]Reported in umhos/cm. Duplicate measurements averaged and reported as a single value.
[3]Sample container broken in transport or analysis.

TOC was found at 3 mg/L or less in the East Sector wells, and phenols were undetected. January measurements of oil and grease ranged up to 5.3 mg/L (within the range of experimental noise for that round), and April measurements ranged from nondetected at 0.1 mg/L to 1.5 mg/L. Nitrate, specific conductance, and pH values were within background ranges and exhibited little contrast from upgradient to downgradient wells. Metals, pesticides, and herbicides sampled at MW-460 and MW-470 were all nondetected except for a trace of 2,4,5-TP in MW-460.

Based on this evaluation, it can be concluded that LF-3 is having no significant impact on downgradient water quality, although monitor wells MW-460 and MW-470 should be sampled again to confirm the absence of VOA's. FT-1 may be contributing some VOA's, particularly TCE, to groundwater, and should be further monitored to confirm the magnitude of VOA's downgradient. Based on their location relative to the direction of groundwater flow, wells in or near the weapon storage area (WSA), i.e., PW-5, PW-6, and TW-19, are more likely to be affected by releases of contaminants within the WSA than by either of the potential source sites investigated.

4.6.2.4 North Sector

One landfill (LF-5) and three disposal pits of indeterminate location were grouped together for the purposes of groundwater investigation into the North Landfill Zone (NLFZ). Four wells (MW-350, MW-360, MW-370, and MW-380) were installed to monitor this zone; one well was to be upgradient. All four wells unexpectedly ended up either upgradient or cross-gradient from the landfill (Subsection 4.2.4.4 and Figure 4-10). Therefore, sampling data for this zone cannot be considered conclusive. Groundwater quality data for the North Sector have been summarized in Tables 4-20 and 4-21.

Of the VOA compounds analyzed, only 1,2-dichloropropane was confirmed, at MW-360 (0.00021 to 0.0015 mg/L). Other VOA compounds detected were trans-1,3-dichloropropene, benzene, and toluene. None of the wells exhibited TOX values consistently in excess of 0.021 mg/L. TOC and phenols were found at or below their detection limit. The highest concentration of oil and grease in the April round was found in MW-370 (2.8 to 4.4 mg/L). Field-measured pH values were within background range, but both specific conductance and nitrates were near or above maximum background levels in MW-360, MW-370, and MW-380. None of the metals, pesticides, or herbicides were detected except for traces of 2,4,5-TP in two wells in the January round.

Table 4-20

Results of Analyses for U.S. EPA Volatile Organic Compounds and TOX,
Monitor Wells, North Sector,
22 January to 1 February and 2 to 11 April 1985

Analyte (mg/l)	Detection Limit (mg/L)	MW-350 Jan	MW-350 Apr	MW-360 Jan	MW-360 Apr	MW-370 Jan	MW-370 Apr	MW-380 Jan	MW-380 Apr
1,2-Dichloropropane	0.0001	ND	ND	0.00021	0.0015	ND	ND	ND	ND
Trans 1,3-Dichloropropene	0.0003	ND	ND	ND	0.0013	ND	ND	ND	ND
Benzene	0.0002	ND	ND	ND	ND	ND	ND	ND	0.00041
Toluene	0.0002	ND	ND	ND	ND	ND	0.00023	ND	ND
Total Organic Halogens (TOX)	0.005	ND	0.014	0.020	0.017	0.013	0.031	0.006	0.005

ND - Not detected above detection limits.

Table 4-21

Results of Analyses for TOC, Inorganics, and Pesticides, Monitor Wells, North Sector, 22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	MW-350 Jan	MW-350 Apr	MW-360 Jan	MW-360 Apr	MW-370 Jan	MW-370 Apr	MW-370 Apr Dup	MW-380 Jan	MW-380 Apr
pH[1]	0.1	7.9	8.2	7.6	7.1	7.9	7.2	7.3	7.2	7.4
Specific conductance[2]	1.0	380	320	580	510	390	420		520	490
Total organic carbon	1.0	ND	ND	ND	ND	ND	ND	ND	ND	1
Oil and grease	0.1	<1.3	ND	5.8	0.4	5.3	2.8	4.4	9.7	1.3
Phenols	0.1	0.1	ND	ND	ND	0.1	ND	ND	ND	ND
Nitrate	0.1	29	27	55	55	47	44	44	49	47
Cadmium	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	0.00002	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lindane	0.00001	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toxaphene	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-D	0.00006	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4,5-TP	0.00006	ND	ND	0.00008	ND	ND	ND	ND	0.00006	ND

ND - Not detected above detection limits.

[1]Reported in standard units.
[2]Reported in umhos/cm.

4.6.2.5 West Flightline Sector

Seven wells were installed to monitor four sites in the West Flightline Sector: MW-390, MW-400, MW-410, MW-420 at the WLFZ; MW-430 at FS1-4; MW-440 at DA-2; and MW-450 at FT-3. Due to the unexpected direction of groundwater flow in this section, only MW-420 can be considered to be directly downgradient of the site monitored, although MW-400 and MW-410 would also be expected to be impacted by the WLFZ (Subsection 4.2.4.5 and Figure 4-11). Therefore, data gathered at the other three sites cannot be considered conclusive for the purposes of establishing presence or absence of contamination in shallow groundwater. All groundwater quality data gathered in this sector have been summarized in Tables 4-22 and 4-23.

A greater number of VOA compounds were detected in the West Flightline Sector than in any other sector, including the following:

• vinyl chloride	confirmed at MW-410	(0.00093 to 0.0022 mg/L)
• trans-1,2-dichloroethene	confirmed at MW-440	(0.0023 to 0.0036 mg/L)
• 1,1-trichloroethane	confirmed at MW-430	(0.010 to 0.022 mg/L)
• Trichloroethylene	confirmed at MW-410	(0.00014 to 0.00054 mg/L)
	confirmed at MW-420	(0.00033 to 0.0037 mg/L)
	confirmed at MW-440	(0.0020 to 0.0083 mg/L)
• tetrachloroethylene	confirmed at MW-450	(0.00006 to 0.00070 mg/L)

However, TOX was not found to consistently exceed 0.021 mg/L in any of the wells sampled.

Table 4-22

Results of Analyses for U.S. EPA Volatile Organic Compounds and TOX, Monitor Wells, West Flightline Sector, 22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	MW-390 Jan	MW-390 Apr	MW-400 Jan	MW-400 Apr	MW-410 Jan	MW-410 Apr	MW-420 Jan	MW-420 Apr	MW-430 Jan	MW-430 Apr	MW-440 Jan	MW-440 Apr	MW-450 Jan	MW-450 Apr	MW-450 Apr Dup
Vinyl chloride	0.0002	ND	ND	ND	ND	0.00093	0.0022	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloro-ethane	0.0005	ND	ND	ND	ND	ND	0.0012	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,2-Dichloro-ethene	0.0001	ND	ND	ND	ND	0.00022	ND	ND	ND	ND	ND	0.0023	0.0036	0.0019	ND	ND
1,2-Dichlo-roethane	0.00002	ND	ND	ND	ND	ND	0.00082	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Tri-chloro-ethane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	0.010	0.022	ND	ND	ND	0.00067	ND
Trans-1,3-Dichloro-propene	0.0003	ND	0.0013	ND	ND	ND	0.00063	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlo-ropropane	0.0001	ND	0.0019	ND	ND	0.00049	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloro-ethylene	0.0001	ND	ND	ND	ND	0.00014	0.00054	0.0037	0.00033	ND	ND	0.0020	0.0083	ND	ND	ND
Tetrachlo-roethene	0.00005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.00006	0.00070	0.00057
Chloro-benzene	0.0003	ND	ND	0.00092	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND - Not detected above detection limit.

Table 4-22
(continued)

Analyte (mg/L)	Detection Limit (mg/L)	MW-390 Jan	MW-390 Apr	MW-400 Jan	MW-400 Apr	MW-410 Jan	MW-410 Apr	MW-420 Jan	MW-420 Apr	MW-430 Jan	MW-430 Apr	MW-440 Jan	MW-440 Apr	MW-450 Jan	MW-450 Apr	MW-450 Apr Dup
1,3-Dichlorobenzene	0.0003	ND	ND	0.00054	ND	ND	0.0020	0.00082	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	0.0002	ND	ND	ND	ND	0.00058	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	0.0002	ND	0.00031	ND	ND	ND	0.00034	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0023	ND	0.0029	ND	ND
Total Organic Halogens (TOX)	0.005	0.011	ND	0.019	0.006	0.016	0.013	0.050	0.011	0.022	ND	0.012	0.0005	0.009	0.006	0.005

ND - Not detected above detection limits.

Table 4-23

Results of Analyses for TOC, Inorganics, and Pesticides,
Monitor Wells, West Flightline Sector,
22 January to 1 February and 2 to 11 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	MW-390 Jan	MW-390 Apr	MW-400 Jan	MW-400 Apr	MW-410 Jan	MW-410 Apr	MW-420 Jan	MW-420 Apr	MW-430 Jan	MW-430 Apr	MW-440 Jan	MW-440 Apr	MW-450 Jan	MW-450 Apr	MW-450 Apr
pH[1]	0.1	7.8	6.0	7.5	7.7	6.9	6.6	7.7	7.5	7.9	7.0	7.9	7.7	7.5	7.6	
Specific conductance[2]	1.0	320	260	390	370	580	580	330	330	480	400	420	400	370	160	
Total organic carbon	1.0	ND	ND	ND	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	ND
Oil and grease	0.1	15	0.8	3.8	0.5	6.7	1.0	<1.0	0.5	3.1	ND	3.5	ND	<1.1	ND	0.8
Phenols	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate	0.1	45	13	50	6	49	22	36	11	---	---	---	---	39	41	41
Cadmium	0.01	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---	---	---	---
Chromium	0.05	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---	---	---	---
Lead	0.02	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---	---	---	---
Mercury	0.001	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---	---	---	---
Silver	0.01	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---	---	---	---
Endrin	0.00002	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---	---	---	---
Lindane	0.00001	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---	---	---	---
Methoxychlor	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---	---	---	---
Toxaphene	0.001	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---	---	---	---
2,4-D	0.00006	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---	---	---	---
2,4,5-TP	0.00006	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---	---	---	---

ND - Not detected above detection limit.
--- - Analysis not requested.

[1]Reported in standard units.
[2]Reported in umhos/cm.

TOC and phenol were generally below detection limits, except for occasional TOC values of 2 mg/L. April measurements of oil and grease ranged from nondetected to a maximum of 0.1 mg/L in MW-410. Nitrate levels in the WLFZ wells were generally above background in January and within background in April. Nitrate levels in MW-450 were above background in both rounds, but did not exceed the Federal MCL of 45 mg/L. Values of pH were generally within background ranges (except for an anomalous value of 6.0 at MW-390); the only well exhibiting consistently high specific conductance was MW-410. None of the metals, pesticides, or herbicides sampled in the WLFZ wells were detected.

Based on this evaluation of the groundwater quality data, the WLFZ appears to be contributing a variety of VOA's at relatively low concentrations to the shallow aquifer, and there is some evidence of mineralization with inorganic (conductive) compounds in MW-410. Two other investigation sites, DA-2 and FT-3, appear to be acting as sources for VOA's, but installation and sampling of downgradient wells will be required to confirm these sites.

4.6.3 Summary of Groundwater Quality Results

The purpose of a Phase II, Stage 1 IRP Study is to establish presence or absence of contamination resulting from a potential source site. The results of the groundwater quality investigation are summarized in Table 4-24 in terms of the confirmation objective. Of 12 investigation sites at CAFB where groundwater was monitored, two have been shown to have had no significant impact on shallow groundwater. At four sites, additional monitor wells are needed to complete the confirmation investigation. At the remaining six sites, the quality of shallow groundwater has been shown to have been impacted by the site. The only Federal MCL exceeded in groundwater at CAFB was the one for nitrate (45 mg/L, as nitrate) in the Main Base area and at three sites: SLFZ, NLFZ, and WLFZ. All three are landfill sites, and landfills are commonly found to be sources of nitrate. Contaminant levels were found to exceed State standards for only two parameters, trichloroethylene and benzene, and at only two sites, the "TCE plume" and DA-8.

Table 4-24

Summary of the Evaluation of Groundwater Quality Results

Sector	Investigation Site Designation	Site Has Impacted Shallow Groundwater: Yes	No	Additional Information Required
Main Base Sector	TCE plume	X		
	DA-8	X		
	DA-3	X		
	DA-6		X	
South Sector	SLFZ	X		
East Sector	FT-1	X		
	LF-3		X	
North Sector	NLFZ			X
West Flightline Sector	WLFZ	X		
	FS1-4			X
	DA-2			X
	FT-3			X

4.7 WATER QUALITY RESULTS FOR SURFACE WATER

This subsection reviews chemical data, including results of both field measurements and laboratory analyses obtained from surface water samples collected at CAFB on 4 March and 8 April 1985. Sampling stations designated as SG-1 through SG-9 were established at locations in the two principal ditches in the Main Base and South Sectors (Figure 3-17). The ditches meet at the southern Base boundary corner, at the exit point for surface drainage from the Base. SG-1 through SG-6 were established to monitor surface water potentially affected by the SLFZ. SG-7 through SG-9 were established to monitor surface water potentially affected by DA-8 (Building 1550 discharge pipe). SG-1 through SG-3 were established in the western drainage ditch (parallel to the Santa Fe Boulevard boundary) and are potentially affected by DA-3 (the CE yard washrack), as well as intermittent runoff from the LF-1 effluent sprayfield. SG-4 was located at the confluence of the two ditches near the Base runoff exit point. SG-5 and SG-6 were located in the eastern ditch, which is affected by intermittent runoff from LF-1, as well as upstream sources including DA-8 and DA-5 (the aircraft washrack).

Methods used in surface water sampling are described in Section 3 and in the Field Sampling and QA/QC Plan (Appendix G). All surface water samples were collected as grab samples within a few feet of the shore. Samples were field filtered for metals analyses, and pH and specific conductance were measured within 6 hours of sample collection. Water levels in the western ditch were 0.2 feet lower in April than in March, but approximately the same in the eastern ditch. The water in both ditches was static in April, with no off-Base overflow. The western ditch was practically dry, and water had to be sampled from individual, algae-rich stagnant pools. The water in these pools had a soapy feel and exhibited relatively high pH values characteristic of detergent solutions. The pH in these pools may also have been affected by discharge of sodium bicarbonate solutions at DA-3, as documented in Base records.

The water quality data obtained have been summarized in Tables 4-25 and 4-26 in Appendix L. The following subsections provide an evaluation of the data on the basis of criteria and water quality standards established in the previous subsections.

Table 4-25

Results of Analyses for U.S. EPA Volatile Organic Compounds and TOX, Surface Water Samples, Main Base and South Sectors, 4 March and 8 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	SG-1 Mar	SG-1 Apr	SG-2 Mar	SG-2 Apr	SG-3 Mar	SG-3 Apr	SG-4 Mar	SG-4 Apr	SG-5 Mar	SG-5 Apr	SG-5 Apr Dup	SG-6 Mar	SG-6 Mar Dup	SG-6 Apr
1,1,1-Trichloroethane	0.0001	ND	ND	0.0026	ND	0.00033	ND	ND	ND	0.0022	ND	ND	0.00010	ND	ND
Trichloroethene	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	0.0002	ND	0.00066	ND	0.00022	ND	0.00033	ND	0.00034	ND	ND	ND	ND	ND	ND
Ethylbenzene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.00038
Total organic halogens (TOX)	0.005	0.043	0.123	0.090	0.031	0.120	0.079	0.044	0.035	0.065	0.052	0.022	0.088	0.035	0.043

ND - Not detected above detection limit.

Table 4-25
(continued)

Analyte (mg/L)	SG-7 Mar	SG-7 Apr	SG-7 Apr Dup	SG-8 Mar	SG-8 Apr	SG-9 Mar	SG-9 Mar Dup	SG-9 Apr
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	0.00011	ND
Trichloroethene	ND	0.0020	0.0022	ND	0.00025	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	0.00026	0.00021	ND	ND	ND	ND	ND
Total organic halogens (TOX)	0.049	0.024	0.031	0.023	0.039	0.041	0.066	0.027

Table 4-26

Results of Analyses for TOC, Inorganics, and Pesticides
Surface Water Samples, Main Base and South Sectors,
4 March and 8 April 1985

Analyte (mg/L)	Detection Limit (mg/L)	SG-1 Mar	SG-1 Apr	SG-2 Mar	SG-2 Apr	SG-3 Mar	SG-3 Apr	SG-4 Mar	SG-4 Apr	SG-5 Mar	SG-5 Apr	SG-5 Apr Dup	SG-6 Mar	SG-6 Mar Dup	SG-6 Apr
pH[1]	0.1	8.6	8.6	8.8	9.8	8.0	10.1	7.5	8.5	7.5	8.5	8.4	7.2	7.3	8.9
Specific conductance[2]	1.0	520	310	840	150	890	430	380	100	330	140			310	210
Total organic carbon	1.0	14	33	23	13	20	34	8.9	7.3	9.8	7.4	7.0	17	18	8.4
Oil and grease	0.1	1.3	1.0	1.5	ND	1.2	0.9	0.7	ND	0.7	0.4	ND	1.5	1.7	0.5
Phenols	0.1	ND	ND	ND	ND	ND	ND	ND	ND	(3)	ND	ND	(3)	ND	ND
Nitrate	0.1	4.2	0.2	6.6	0.1	11	ND	8.6	0.7	2.8	0.5	0.5	4.2	4.1	1.0
Cadmium	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	0.00002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lindane	0.00001	0.00002	ND	0.00005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toxaphene	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-D	0.00006	ND	ND	ND	0.00054	ND	0.0028	ND	ND	0.00011	ND	ND	0.0024	0.0022	ND
2,4,5-TP	0.00006	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.00007	0.00008	ND

ND - Not detected above detection limit.
--- - Analysis not requested.

[1]Reported in standard units. Duplicate measurements averaged and reported as a single value.
[2]Reported in umhos/cm. Duplicate measurements averaged and reported as a single value.
[3]Sample container broken in transport or analysis.

Table 4-26
(continued)

Analyte (mg/L)	SG-7 Mar	SG-7 Apr	SG-7 Apr Dup	SG-8 Mar	SG-8 Apr	SG-9 Mar	SG-9 Mar Dup	SG-9 Apr
pH[1]	7.4	9.1	9.1	7.4	9.0	8.3	8.4	8.9
Specific conductance[2]	230	290	---	300	260	---	270	300
Total organic carbon	23	10	9.0	19	14	14	(3)	20
Oil and grease	2.0	0.5	0.5	0.9	ND	0.7	0.6	ND
Phenols	---	---	---	---	---	---	---	---
Nitrate	---	---	---	---	---	---	---	---
Cadmium	---	---	---	---	---	---	---	---
Chromium	---	---	---	---	---	---	---	---
Lead	---	---	---	---	---	---	---	---
Mercury	---	---	---	---	---	---	---	---
Silver	---	---	---	---	---	---	---	---
Endrin	---	---	---	---	---	---	---	---
Lindane	---	---	---	---	---	---	---	---
Methoxychlor	---	---	---	---	---	---	---	---
Toxaphene	---	---	---	---	---	---	---	---
2,4-D	---	---	---	---	---	---	---	---
2,4,5-TP	---	---	---	---	---	---	---	---

4.7.1 Data Review

In general, the observations made for groundwater data in Subsection 4.6.1.1 also apply to surface water. However, conditions affecting surface water are much more variable over short periods of time than those affecting groundwater; therefore, more contrast occurs between sampling rounds, and comparison of results between rounds cannot be used to confirm the presence of a parameter. Significant concentrations of naturally-occurring organic compounds are found in some surface water, and may affect "lumped" determinations such as TOC. In addition, because no samples could be collected from stations upstream of all potential sources, it is more difficult to establish true background values for each of the analytes in surface water.

The full list of analytes was sampled in both rounds at SG-1 through SG-6. Of these, the following were not detected at any of the six stations in either round: phenols (two sample containers were broken), cadmium, chromium, lead, mercury, silver, endrin, methoxychlor, or toxaphene.

In the first round, traces of lindane (0.00002 and 0.00005 mg/L) were detected at SG-1 and SG-2; the herbicide 2,4-D was detected at SG-5 (0.00011 mg/L), and both 2,4-D and 2,4,5-TP (averaging 0.0023 and 0.00008 mg/L, respectively) were detected at SG-6. In the second round, traces of 2,4-D (0.00028 and 0.00054 mg/L) were detected at SG-2 and SG-3. TOC values around the SLFZ ranged from 7 to 33 mg/L, and exhibited no particular seasonal trend, although they tended to be higher in the western ditch (SG-1 through SG-3) than in the eastern ditch (SG-4 through SG-6). Oil and grease concentrations ranged from nondetected at 0.1 mg/L to 1.4 mg/L; they generally decreased slightly between March and April. Nitrate values ranged from nondetected at 0.1 mg/L to 11 mg/L, and decreased from March to April. Values of pH ranged from 7.2 to 10.1, increasing from March to April, with highest pH values measured in the stagnant ponds in the west ditch in April. There was also a significant decrease in specific conductance between rounds (from 310 to 890 umhos/cm to 100 to 430 umhos/cm), most likely related to the concentration of detergents or other conductive materials in the stagnant ditch water.

Besides VOA compounds, only TOC and oil and grease were sampled for laboratory analysis at SG-7 through SG-9. Values for both of these compounds, as well as field-measured pH, fell within the ranges measured at SG-1 through SG-6. Field-measured specific conductance was relatively constant, ranging only between 230 and 300 umhos/cm.

VOA compounds, including MEK, were analyzed at all nine surface water stations in both rounds. In the first round, only 1,1,1-trichloroethane (TCA) was detected at five stations in both ditches at concentrations less than 0.0026 mg/L. In the second round, benzene was detected at SG-1 through SG-4, with a maximum concentration of 0.00066 mg/L at SG-1. Ethylbenzene was detected at two stations, SG-6 and SG-7, at concentrations of 0.00038 and 0.00024, respectively. Trichloroethylene was detected as the highest concentration at SG-7 (0.0021 mg/L) and SG-8 (0.00025 mg/L), both downstream from DA-8, but not at SG-9, the surface water station closest to Building 1550. Clearly, most compounds were more concentrated (with the exception of nitrate), and a wider variety of analytes were detected under dry-weather conditions.

Because TCE has not been used at the Base since 1976, it is unlikely to have occurred in the ditch system from ongoing spills, but were more likely from seepage into the ditch.

4.7.2 Federal and State Water Quality Standards

Of the water quality standards listed in Table 4-7, only the standard for pH was exceeded. The standard of 8.5 for pH was exceeded at SG-1 through SG-3 in most rounds, and at all other stations in April only.

4.8 CONCLUSIONS

Following are conclusions related to the confirmation stage investigation of 16 sites encompassing 28 potential contaminant source sites at CAFB. The first two subsections review general conclusions which have been drawn from this investigation concerning hydrogeology and soil and water quality. The third subsection classifies the sites by category according to the need for further investigation and/or remediation. Investigation alternatives are reviewed in Section 5, and specific recommendations for each site are detailed in Section 6.

4.8.1 General Conclusions: Hydrogeology

The following are general conclusions concerning the regional geologic and hydrogeologic setting at CAFB:

- Three separate producing aquifers can be distinguished in the subsurface below CAFB. The deepest, comprising the upper portion of the Mehrten Formation, occurs approximately below a depth of 800 feet. A confined aquifer, tapped by the Main Base and family housing production wells, occurs between depths of 260 and 300 feet. The new production well draws water from both the deep and confined aquifer. The shallow aquifer consists of a wedge of coarse sands and gravel that appears to thicken and increase in permeability westward beneath the Base. In the Main Base Sector, the shallow and confined aquifers are separated by approximately 150 feet of predominantly clayey sediments and there is a slight downward hydraulic gradient (on the order of 0.01). The degree of separation or connection between the two aquifers in off-Base areas to the west and southwest is unknown.

- The shallow aquifer is locally overlain by clay lenses which may support perched groundwater; the presence of perched groundwater could not be confirmed by use of mud rotary drilling techniques. The shallow aquifer is considered semiconfined.

- Although hardpan is frequently encountered in shallow soils, hardpan zones do not appear to be laterally continuous, or to provide effective barriers to vertical infiltration. Perched saturated zones were not encountered in the lysimeters finished on top of hardpan.

- Groundwater flow direction in the shallow aquifer beneath CAFB converges toward a northeast-southwest trending trough and exits the area of the Base primarily across the southwestern boundary in the Main Base Sector. Thus, groundwater flow directions in the North and West Flightline Sectors are reversed from the presumed flow direction used in monitor well placement in Stage 1, and additional mo-itor wells are needed to complete the confirmation stage investigation in those sectors. The only area in which groundwater flow direction was observed to be directly affected by pumping was in the WLFZ, where flow directions were affected by pumping from an off-Base irrigation well.

4.8.2 General Conclusions: Soil and Water Quality

The following are general conclusions concerning soil and water quality data collected at CAFB in the course of this investigation:

- Based on sampling and analysis results, it is concluded that the soils and sediments have not been significantly impacted by the sites sampled at CAFB, although some residual and relatively immobile petroleum byproducts may be present at DA-1 and DA-3. These products may continue to accumulate under current disposal practices at these sites unless these practices are curtailed.

- Of the analytes sampled in surface water from nine staff gage stations in drainage ditches in the Main Base and South Sectors, only pH consistently exceeded the Federal water quality standard of 8.5, at three stations in the west ditch paralleling Santa Fe Boulevard. This has been related to quantities of either detergent solutions or sodium bicarbonate reaching this ditch from DA-3. Traces of VOA compounds and pesticides and herbicides found in both sampling rounds indicate that miscellaneous other discharges may be affecting the ditches, but no significant impact was observed from direct runoff or seepage of sewage effluent sprayed in the LF-1 area. Traces of TCE detected at two surface water sampling stations downstream from DA-8 may be related to seepage from the old TCE overflow pipe in the bank of the ditch; four buried segments of pipe were identified from geophysical surveys between Building 1550 and the ditch, one of which may correspond to the TCE source pipe.

- Nitrate concentrations in the shallow aquifer (actually measured as total nitrate, and nitrite as nitrate) were found to exceed the Federal drinking water standard of 45 mg/L in the Main Base sector and in the area of three landfills: SLFZ, NLFZ, and WLFZ. Due to the location of CAFB in a predominantly agricultural region that is criss-crossed by irrigation supply and drainage canals, levels of nitrate up to 30 mg/L in groundwater are thought to represent normal background levels in the shallow aquifer. The highest nitrate concentrations, downgradient of LF-1 in the SLFZ (ranging up to 74 mg/L), correspond closely to elevated levels of specific conductance, and are thought to have been contributed from landfill leachate, spray effluent, or a combination of the two.

- The only other analyte which was found to exceed Federal or State-regulated water quality standards on a widespread basis in the shallow aquifer was TCE. Maximum measured concentrations of TCE were over 0.250 mg/L, or 50 times the California DHS action level of 0.005 mg/L. The TCE contour map in Figure 4-18 illustrates a plume of TCE contamination originating in the Main Base Sector and moving off-Base across the western boundary in the vicinity of the Main Gate. Although the source of the TCE contamination was not positively identified, further investigation at both DA-8 and an old shop building is indicated based on the shape of the plume and current information on groundwater flow direction.

- Samples from Main Base production wells PW-1, PW-2, PW-3, and PW-4 exhibited TCE concentrations ranging up to 0.044 mg/L in PW-3. Indirect evidence from the PW-3 pilot test investigations indicated the presence of significant void spaces around the outside of the casing in that well, resulting in initial bypassing of the grout mixture through the perforations into the well bottom. This evidence and the existence of a downward vertical gradient in the vicinity of PW-3 tend to support the hypothesis of down-casing leakage between the shallow and confined aquifers. Results of a 4-week pumping test at the end of well reconstruction indicated that long-term pumpage from PW-3 would exhibit a sustained TCE concentration averaging 0.010 mg/L. Based on a measured TCE concentration of 0.044 mg/L under static conditions after the pilot test, which corresponds closely to pre-pilot test conditions, the hypothesis of localized contamination in the confined aquifer only in the immediate vicinity of the Main Base production wells could not be confirmed. Further investigation will be required to evaluate the magnitude of contamination in this aquifer. This is particularly important because after February 1985, the new production well became the principal Main Base supply well. This well is open to both the confined and deep aquifers, and provides a new driving force for contamination to spread in the confined aquifer.

4.8.3 Site-Specific Conclusions

As a conclusion to the investigation, each of the sites investigated can be categorized according to whether it requires no further action (Category I), requires further investigation (Category II), or is ready for remedial action (Category III). Sites may be subsequently recategorized at the end of each successive stage of the Phase II investigation until all are ready for remedial action (Phase IV of the IRP investigation) or no action. The following definitions have been used in the classification of investigation sites at CAFB:

- Category I applies to sites where no further action (including remedial action) is required.
- Category II applies to sites requiring additional investigation to quantify or further assess the extent of current or future contamination.
- Category III applies to sites where remedial action is required and all necessary data to support an analysis of remedial alternatives have been gathered. These sites are considered ready for IRP Phase IV action.

Site-by-site conclusions are summarized in Table 4-27, which lists a category for each site, presents the rationale for that categorization, and references the report subsections that present supporting evidence for that categorization. Investigation alternatives for each category are reviewed in Section 5, and site-specific recommendations are presented in Section 6.

Table 4-27

Summary of Site-Specific Conclusions, Castle Air Force Base IRP Phase II, Stage 1 Investigation

Sector	Investigation Site	Investigation Category	Rationale	Supporting Subsections of Report
Main Base Sector	1. TCE Plume	II	Confirmed TCE contamination in shallow aquifer migrating off-Base and requiring remedial action, due to threatened private and public water supplies; further investigation required to confirm source and estimate extent of contamination in confined aquifer.	4.3 4.6.2.1
	2. DA-8	II	Confirmed TCE contamination in shallow aquifer; further investigation required to confirm presence and quality of perched groundwater above shallow clay. Possible segments of discharge pipe located by geophysical surveys.	4.2.4.1 4.4.1 4.5.2.1 4.6.2.1 4.7
	3. DA-5	I	No evidence of contamination; no further investigation required except in conjunction with DA-8 and FITS area as a whole.	
	4. DA-7	I	No evidence of contamination with pesticides or herbicides in soil at DA-7, or anywhere in groundwater.	4.5.1.1
	5. DA-3	II	Confirmed contamination with with oily substance in TW-17, visual evidence of dry-well disposal; confirmed elevated oil and grease in ditch sediments.	4.5.2.3 4.6.2.1 4.7

Table 4-27
(continued)

Sector	Investigation Site	Investigation Category	Rationale	Supporting Subsections of Report
Main Base Sector (continued)	6. DA-6	I	No evidence of groundwater contamination directly associated with this site in TW-13 or other wells.	4.6.2.1
South Sector	7. SLFZ-general	III	Confirmed effluent application. Confirmed groundwater contamination with inorganics and trace organics. No unacceptable health or environmental risks at current levels.	4.6.2.2 4.7
	7a. SLFZ - DA-1	I	Confirmed elevated oil and grease levels in soils, but no VOA's. Groundwater is adequately monitored by existing SLFZ network.	4.5.1.2
	7b. SLFZ - DP-3	I	Probable fill and possible buried drums detected in geophysical surveys; however, groundwater is adequately monitored by existing SLFZ network.	4.4.2
East Sector	8. FT-1	II	Confirmed trace organic contamination in shallow groundwater, occasional TCE in excess of CDHS action levels.	4.6.2.3
	9. LF-3	II	Unconfirmed contamination with TCE in one round.	4.6.2.3

Table 4-27
(continued)

Sector	Investigation Site	Investigation Category	Rationale	Supporting Subsections of Report
North Sector	10. NLFZ	II	Evidence of crushed and buried drums from visual and verbal reports; probable buried drums in trenches detected from geophysical surveys; some preliminary evidence of shallow groundwater contamination with inorganics, but monitor wells not located to sample downgradient groundwater.	4.2.4.4 4.4.3 4.6.2.4
West Flightline Sector	11. WLFZ	II	Confirmed impact on shallow groundwater from contamination with inorganics, trace organics, proximity to off-Base pumping well. Needs closer downgradient wells.	4.5 4.6.2.5
	12. PCB 1-3	Not Investigated	Ongoing Base-initiated clean up.	3.2.2
	13. FS1-4	II	Monitor well not located to sample downgradient groundwater.	4.2.4.5 4.2.6.5
	14. DA-2	II	Monitor well not located to sample downgradient groundwater. Some preliminary evidence of contamination with VOA's.	4.2.4.5 4.6.2.5
	15. DA-4	II	No evidence of contamination in soil. Monitor well recommended due to presence of miscellaneous VOA's in shallow groundwater in the West Flightline Sector from upgradient sources.	4.5.1.3 4.2.6.5
	16. FT-3	II	Monitor well not located to sample downgradient groundwater.	4.2.4.5 4.6.2.5

SECTION 5

ALTERNATIVES

5.1 GENERAL

Based on the results of this investigation, 17 sites (including two subsites of the SLFZ) have been classified into one of three possible categories: Category I, requiring no further action; Category II, requiring further investigation; or Category III, requiring remedial action. Of the 17 sites, one (the SLFZ) fell in Category III, and five (including the two subsites of the SLFZ) fell in Category I. All five of the sites in Category I (requiring no further action) are located within larger areas requiring further action. Eleven sites were found to be in Category II, requiring further investigation. This section reviews the principal investigation alternatives associated with Category II which are applicable to sites at CAFB.

Table 5-1 summarizes the types of site investigation alternatives commonly available, listing the subcategories to which these alternatives would be applicable, conditions and rationale for applicability, and the specific sites at which the investigation alternative was found to be applicable. Three broad types of investigation alternatives have been identified in Table 5-1: 1) additional sampling at existing monitor points, 2) use of nondestructive geophysical methods, 3) soil gas testing, and 4) expansion of monitoring network. Of these, further use of geophysical methods has been determined to have little applicability at CAFB for the following reasons:

- Of the sites requiring further investigation, only the NLFZ is suspected of containing numerous buried metal drums, and an extensive investigation of the location of buried drum nests has already been performed (Subsection 4.4.3).

- Although hydrogeological conditions are favorable for tracking of a contaminant plume downgradient from a site by geophysical methods, the types of contaminants detected (mostly nonconductive organics) and the conductivity contrasts observed in the shallow aquifer do not readily lend themselves to these methods.

Table 5-1

Summary of Investigation Alternatives for Category 2 Sites

Investigation Alternative	Condition(s) of Applicability	Rationale for Recommendation	Applicable Sites at CAFB
Use of nondestructive geophysical methods (GPR, magnetometer, electrical resistivity, electromagnetic inductance).	Existing monitoring network is insufficient to confirm contamination resulting from past site use or operation.	Geophysical methods can provide initial screening of the site for contrasts in subsurface characteristics representing buried material or mineralized groundwater.	
	Contamination from the site has been confirmed, but additional data are required to quantify contamination.	Geophysical methods can be used to delineate the extent of a site and track contaminants migrating away from a site.	
	Data are sufficient to support a preliminary alternatives analysis, but further data are required for quantification.	Geophysical methods can be used to delineate the extent of a site and track contaminants migrating away from a site.	
Soil gas testing	(as above)	Soil gas testing can provide initial screening of the site for the presence of volatile organic compounds in soil and/or groundwater.	TCE plume, DA8, DA3, fire training area 1, and west flightline sector.
	(as above)	Soil gas testing can be used to delineate the extent of soil and/or groundwater contamination of volatile organic compounds present on-site and migrating off-site.	
Expansion of monitoring network including additional sampling at new and/or existing monitor points:	(as above)	Additional or repeated monitor at critical locations can be used to complete confirmation study of a site.	North landfill zone, fuel spills 1 to 4, discharge area 2, discharge area 4, and fire-training area 3.
a. Collect additional soil samples. b. Establish additional surface water sampling stations. c. Install additional groundwater monitoring wells.	(as above)	Additional monitoring points provide new quantitative chemical data in the lateral and vertical dimensions for determining the distribution of contaminants in both dimensions, as a basis for developing remedial alternatives and monitoring effectiveness of remedial actions implemented.	Discharge area 8, discharge area 3, west landfill zone, and TCE plume.

Therefore, further site investigations recommended will depend primarily on additional sampling at existing and new monitor points. The following subsection reviews the rationale affecting the selection of investigation alternatives and the development of specific recommendations at the 12 sites determined to require further investigation.

5.2 SITE-SPECIFIC ALTERNATIVES

5.2.1 TCE Plume Alternatives

Based on the results of the Phase II, Stage 1 investigation, the extent of the TCE plume in the shallow aquifer in the Main Base Sector has been defined, except along its north-northwestern edge. The direction of groundwater flow in the shallow aquifer has been shown to be toward off-Base, downgradient areas to the southwest. Questions remain concerning the following factors:

- Location of the source(s) of TCE contamination in the groundwater.
- Presence of perched groundwater beneath the source(s) of TCE.
- Extent of contamination in the deep aquifer on- and off-Base.
- Degree of communication between the shallow and deep aquifers.

Due to the potential threat to off-Base private and public drinking water supplies, an accelerated program is needed to resolve these remaining questions and to analyze the potential remedial alternatives. Soil gas testing, which involves a portable GC unit to measure low concentrations of halocarbons (including TCE) in shallow soil gas, is seen as a key investigative tool in this accelerated program; it can be used to track the plume of contaminated groundwater in a downgradient direction off-Base, to better define the plume in the shallow aquifer on-Base, and to investigate the presence of pockets of contamiated soil in upgradient areas in the Main Base Sector (e.g., in the area of Building T-52). Additional monitor wells will be required to confirm the results ot the soil gas testing and to further investigate the presence of TCE in the deep aquifer.

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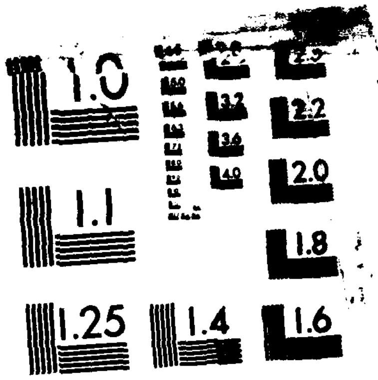

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5.2.2 DA-8 Alternatives

Based on the results of this investigation, TCE is being contributed to groundwater from the area of the FITS squadron maintenance buildings, in the general vicinity of DA-8. The historic existence of a TCE-overflow pipe draining to the ditch from Building 1550 could not be confirmed verbally (through interviews or visually) during the course of this investigation, although several underground pipe segments were located by means of combined GPR and magnetometer surveys. Most likely, the two drainage ditches forming the perimeter of the FITS area have acted as diffuse sources of contaminant recharge to groundwater from a variety of historic spills and long-term sources, including DA-8 and DA-5. For this reason, low-water monitoring of surface water stations SG-7 and SG-8 should be continued. Soil gas testing could be used to investigate further the presence of contaminated soil in the FITS area, particularly in the area of the pipe segments and along the ditch banks. A shallow green plastic clay was encountered in the monitor wells associated with DA-8, underlying the shallow aquifer. Additional borings, to be finished as monitor wells, if applicable, would be required to investigate the lateral continuity of this clay and the presence and chemistry of perched groundwater above it, if any is present.

5.2.3 DA-3 Alternatives

Effluent from the CE washrack was visually observed to be discharged to sumps or "dry wells" between the washrack and the ditch. In addition, an oily substance was observed in groundwater pumped from TW-17, and had been reported as early as August 1984 in Base documents. Soil gas testing, additional monitor points, and an analytical protocol designed to "fingerprint" the substance for identification would be required to further investigate the type and extent of groundwater and soil contamination in this area.

5.2.4 FT-1 Alternatives

Based on the results of this investigation, some degree of groundwater contamination with VOA's is occurring downgradient from FT-1. This area is remote; however, it is partially upgradient from a Base drinking water supply (PW-5 and PW-6). Additional investigation by means of soil gas testing, borings, and additional wells (if necessary) will be required to determine the extent of contamination and the need for remediation.

5.2.5 LF-3 Alternatives

Based on the results of this investigation, LF-3 is most likely not an active source of contamination to groundwater. However, because an anomalously high value of TCE was detected in one round, existing monitor wells should be sampled for two more rounds to confirm the absence of significant VOA concentrations downgradient of LF-3. If absence is confirmed, this LF-3 could be recategorized into Category I (no action required).

5.2.6 Alternatives for NLFZ, FS1-4, DA-2, DA-4, and FT-3

At five investigation sites, the groundwater monitoring network was found to be inadequate for confirmation study due to the unexpected direction of groundwater flow (NLFZ, FA1-4, DA-2, and FT-3) or the lack of any groundwater monitoring points (DA-4). A total of six new monitor wells, constructed similarly to existing monitor wells, would be required to complete the confirmation stage monitoring network at these sites. Soil gas testing should be used prior to monitor well installation to better define areas of soil and/or groundwater contamination. Soil borings, to be completed as perched aquifer monitor wells, if appropriate, should be used to confirm the findings of the soil gas testing.

5.2.7 WLFZ Alternatives

Slight contamination with a variety of VOA compounds has been confirmed at the WLFZ. In addition, the WLFZ is adjacent to the western bounda-y, and groundwater flow in the area has been shown to be affected by off-Base pumping. For these reasons, further investigation is required. Investigation alternatives considered for the site should include: soil gas testing, location of two new monitor wells downgradient from and closer to the WLFZ, to be constructed similarly to the new monitor wells; investigation of the presence of perched groundwater on shallow clay by means of shallow borings and monitor wells; and adjustment of the analytical protocol to include constituents characteristic of landfill leachate and additional parameters for which water quality standards exist.

SECTION 6

RECOMMENDATIONS

As a result of the IRP Phase II, Stage 1 investigation at CAFB, 11 sites were identified requiring further investigation either to complete the confirmation study or to further quantify the extent of contamination. Based on a review of the alternatives in Section 5, the three types of investigation alternatives applicable at CAFB are additional sampling at existing monitor points only, soil gas testing, and expansion of the monitoring network followed by additional sampling. The rationales justifying selection of these alternatives have been reviewed in Section 5. This section presents recommendations for implementation of these alternatives on a site-by-site basis. In addition, one site (SLFZ) has been classified as a Category II site. Specific recommendations for Phase IV actions at that site are also presented below. The site-by-site recommendations are preceded by some general recommendations concerning monitoring of drinking water supplies at CAFB and handling and disposal of hazardous substances, as well as further monitoring programs associated with the IRP.

6.1 GENERAL RECOMMENDATIONS

The following general recommendations are made:

- Although no VOA compounds were found in soils sampled at CAFB and only traces of VOA's, pesticides, and herbicides in surface water from the drainage ditches, other evidence (the presence of oil and grease in soil at DA-1, the presence of detergent and a relatively-high pH in the western perimeter ditch) suggests that on-going discharge to these media could carry hazardous substances, particularly solvents, fuels, and other petroleum byproducts, into the environment. It is recommended that all discharge of wash-waters and nonaqueous substances directly to soils or to the ditches be curtailed, and that these solutions be routed to the industrial sewers instead.

- The confined aquifer has been shown to be contaminated with TCE and associated VOA compounds in the Main Base Sector in the immediate vicinity of PW-1 through PW-4. Currently, these wells are out-of-service, and the Main Base and family housing areas are supplied by other wells also perforated, at least partially, in the confined aquifer. These supply wells are potentially threatened by contamination in the confined aquifer, especially since containment is no longer provided by pumping from the old Main Base production wells. In addition, traces of VOA compounds have been detected in PW-5, PW-6, and PW-11 in the East Sector. For these reasons, it is recommended that all drinking water supply wells be sampled routinely for analysis of the 32 VOA compounds on the U.S. EPA priority pollutant list.

- Of the analytes sampled in Stage 1, the following were found to be universally at or near the detection limit: TOC, oil and grease, and phenols. Furthermore, TOX was found to have relatively poor correlation with halogenated VOA compounds at the concentrations found in groundwater at CAFB. It is therefore recommended that these four parameters be dropped from future sampling and analytical protocols associated with site investigations at CAFB. Instead, it is recommended that the VOA analysis become the principal analytical tool for investigation. At landfill sites thought to be potentially contributing a significant load of inorganics to groundwater, it is recommended that arsenic, chloride, sulfate, and boron be added to the sampling and analtyical protocol. At those landfill sites where metals, pesticides, and herbicides have not been detected in at least two rounds, these analytes should be dropped from the protocol. In addition, all monitor wells should be tested for the presence of free product on water. Where a free product is encountered, it should be sampled and submitted for petroleum hydrocarbon identification analysis. This analysis, referred to as petroleum hydrocarbon identification or GC Scan, uses capillary gas chromatograph methods to "fingerprint" the product, which can then be compared to samples of known products for the purposes of identification.

- The nine lysimeters installed in this study were dry during both sampling rounds. The lysimeters should be checked for the presence of water monthly for one year. If water is found in a lysimeter, it should be sampled at that time following the recommended site-specific protocol (see Table 6-1). If no water is found in the lysimeters after one year of testing, they should be discontinued as monitoring points, removed, and the area backfilled.

6.2 SITE-SPECIFIC INVESTIGATION RECOMMENDATIONS

Site-specific recommendations for further field investigations at 11 sites have been summarized in Table 6-1. Soil gas testing for volatile organic compounds (including halocarbons such as TCE and fuel byproducts where appropriate) has been recommended in three out of five sectors. The rationales for recommending additional wells in the shallow aquifer are provided in Section 4 and Section 5. New wells in the shallow aquifer should be constructed of the same materials used in the Stage 1 monitor wells. At nine sites, additional soil borings to confirm the results of the soil gas testing have been recommended. Where the shallow aquifer is found to be overlain by clay supporting a perched aquifer, it is recommended that additional monitor wells be completed in the perched aquifer. It is recommended that these wells consist of 4-inch PVC pipe with factory slotted screen installed just above the clay by auger methods.

The rationale for choice of analytes is given in Section 5 and Subsection 6.1. In general, at least two more rounds of sampling are recommended at all sites requiring further investigation before Phase II investigations are completed and Phase IV is initiated, or before a site can be dropped into Category I based on two successive rounds showing no evidence of unacceptable hazards.

The TCE plume is the site of most immediate concern at CAFB because is poses the most direct potential threat to drinking water supplies. Contamination associated with the TCE plume in the shallow aquifer can be considered to be fairly well-defined within the Base boundaries on the basis of current information. Due to evidence of off-Base migration of the plume, it is recommended that an analysis of remedial alternatives be initiated along with further site investigations to develop and evaluate recommendations for containment and clean-up in the shallow aquifer and the deep aquifer if necessary.

Table 6-1

Summary of Investigation Recommendations

Sector	Site	Existing Monitor Wells		Recommended New Monitor Wells		Recommended Soil Borings/ Perched Aquifer Wells	Recommended Surface Water Sampling Points	Recommended Analytes in Water	Recommended Additional Field Activities
		Confined Aquifer	Shallow Aquifer	Confined Aquifer	Shallow Aquifer				
Main Base Sector	TCE plume	PW-1, PW-2, PW-3, PW-4	MW-210, MW-220, TW-13, TW-14, TW-15, TW-16, TW-17, TW-18	6	12	12	---	VOA	Soil gas testing
	Discharge Area 8	---	MW-290, MW-300, MW-310	---	---	6	2	VOA	Soil gas testing
	Discharge Area 3	---	TW-17	---	3	3	---	VOA, petroleum hydrocarbon ID	Soil gas testing
East Sector	Fire-Training Area 1	---	MW-320, MW-330, MW-340	---	2	4	---	VOA	Soil gas testing
	Landfill 3	---	MW-460, MW-470	---	---	---	---	VOA	---
North Sector	North Landfill Zone	---	MW-350, MW-360, MW-370, MW-380	---	2	---	2	VOA, nitrate, chloride, sulfate, arsenic, boron, metals, pesticides and herbicides	---

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Table 6-1
(continued)

Sector	Site	Existing Monitor Wells Confined Aquifer	Existing Monitor Wells Shallow Aquifer	Recommended New Monitor Wells Confined Aquifer	Recommended New Monitor Wells Shallow Aquifer	Recommended Soil Borings/ Perched Aquifer Wells	Recommended Surface Water Sampling Points	Recommended Analytes in Water	Recommended Additional Field Activities
West Flight-line Sector	West Landfill Zone	---	MW-390, MW-400, MW-410, MW-420	---	2	3	---	VOA, nitrate, chloride, sulfate, arsenic, boron	Soil gas testing
	Fuel Spills 1 to 4	---	MW-430	---	1	1	---	VOA, petroleum hydrocarbon ID	Soil gas testing
	Discharge Area 2	---	MW-440	---	1	1	---	VOA	Soil gas testing
	Discharge Area 4	---	---	---	1	1	---	VOA	Soil gas testing
	Fire-Training Area 3	---	MW-450	---	1	1	---	VOA	Soil gas testing
Total Recommended New Sampling Points:				6	25	32	4		

Questions remain concerning three critical factors: 1) the source of contamination (where is it located and is it a currently active source?), 2) the degree of communication between the shallow and the confined aquifers in off-Base areas, and 3) the extent of contamination in the confined aquifer. The following specific recommendations for further investigation have been developed to address those questions:

- Conduct additional record search and interviews of Base personnel to identify additional potential sources of TCE in the Main Base area.

- Conduct a thorough review of all available documentation on well logs and geology reports for wells downgradient of the Base. This review will serve to evaluate the degree of communication between aquifers occurring either naturally, through "windows" in the confining clay layers, or artifically, through wells perforated or gravel-packed in more than one aquifer. This study, to be performed in cooperation with state and local agencies (County Health Department, City of Atwater, Merced Irrigation District), should include a field check of each well to sound it and collect a water level measurement, and sampling of selected wells for VOA compounds.

- Test shallow soil gas for the presence of halogenated VOA compounds in up to 75 locations on-Base in the Main Base Sector and off-Base in the area of presumed downgradient migration of TCE in the groundwater. Use soil gas testing for the purposes of both locating sources of TCE in soil and for tracking the downgradient migration in groundwater.

- Install up to 12 additional wells in the shallow aquifer on- and off-Base to confirm the results of the soil gas testing, to further define the plume, and to ascertain the degree of contamination in the shallow aquifer immediately overlying the new PW.

- Install up to six monitor wells in the confined aquifer to ascertain the extent of contamination in that aquifer. These wells will have to be specially constructed by grouting a casing into the confining clay separating the shallow and confined aquifers, and drilling through it into the confined aquifer, so as to ensure that the new monitor wells do not act as conduits between aquifers.

6.3 SITE-SPECIFIC REMEDIAL INVESTIGATIONS

One site, the SLFZ, has been classified in Category III, requiring Phase IV action. IRP Phase IV actions include site remediation actions and long-term monitoring actions.

Based on this investigation, the South Landfill Zone has been shown to have affected shallow groundwater quality by contributing conductive (i.e., inorganic) constituents, primarily from the area of LF-1. None of the parameters identified, however, were found to exceed Federal or state water quality standards. Although the existing monitoring network is adequate to monitor upgradient and downgradient groundwater, the analytical protocol should be designed to monitor constituents characteristic of landfill leachate (e.g., boron), as well as additional compounds for which water quality standards exist (e.g., chloride, sulfate, arsenic) to confirm that no health or environmental hazards are associated with leachate generation or continued spraying of sewage effluent on the fill area.

It is recommended that a routine monitoring program be instituted and be continued at least one year after cessation of effluent application. No other Phase IV actions are recommended for the site based on currently available data.

WESTON

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